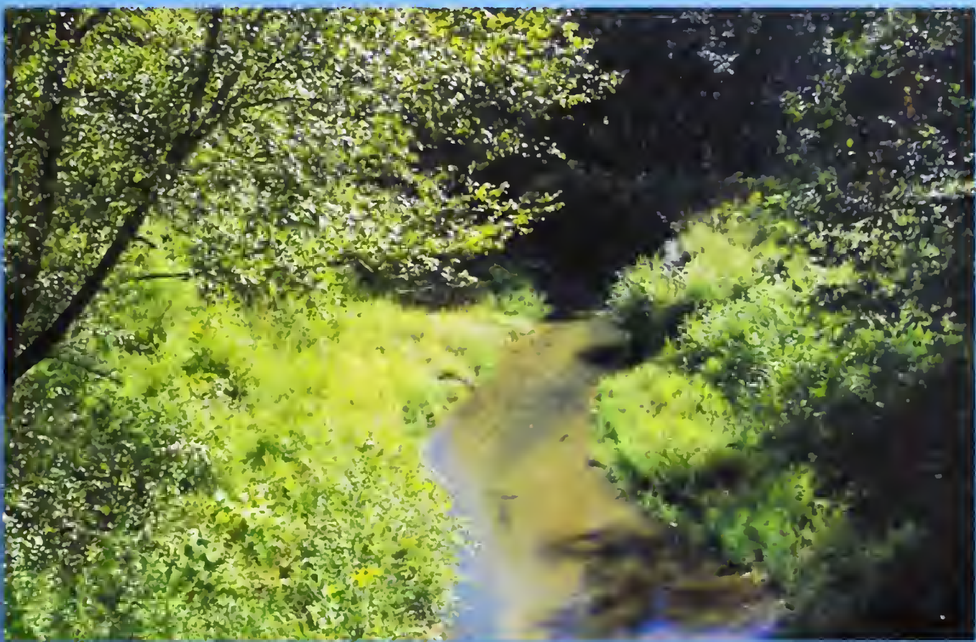
Water Quality & Ecological Processes Research Unit
National Sedimentation Laboratory
Oxford, Mississippi 38655

Water Quality in Northern Mississippi Hill Land Streams in the Demonstration Erosion Control (DEC) Project During Calendar-Year 2002, With Emphasis on Chlorophyll



Richard E. Lizotte, Jr., Charles M. Cooper, Alfred T. Mikell, Jr., Matthew T. Moore, Scott S. Knight, and James T. Hill

Research Report No. 40

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EXECUTIVE SUMMARY

Statement of Purpose

As part of the Demonstration Erosion Control (DEC) Project in the Yazoo Basin, the Water Quality and Ecological Processes Research Unit at the USDA-ARS National Sedimentation Laboratory was requested by the US Army Corps of Engineers, Vicksburg District, to characterize current water quality. The DEC project in the Yazoo Basin is a cooperative interagency project, including the US Army Corps of Engineers, the USDA Natural Resources Conservation Service and the USDA Agricultural Research Service. The projects' primary goals are aimed at flood control, reducing erosion and channel instability with additional goals including demonstration of innovative management techniques, total watershed planning and water quality and environmental enhancement. Currently, on-going consistent water quality characterization is performed in seven hill land stream watersheds as part of a larger database including habitat, animal and plant diversity. Results provide a constant evaluation of DEC water quality conditions and long-term changes. Physical, chemical and biological water quality measures aid in assessing ecosystem health across trophic levels from primary producers (plants and algae) to predatory animals such as fish.

Evaluation

Water samples from each watershed were routinely collected either on a two-week or monthly schedule. Physical, chemical and biological water parameters measured were pH, temperature, dissolved oxygen, conductivity, salinity, turbidity, alkalinity, hardness, depth to water, depth of water, total, suspended and dissolved solids, filtered orthophosphate, total phosphorus, ammonia, nitrate, nitrite, total nitrogen, chlorophyll *a*, *b*, *c*, and total chlorophyll, fecal coliforms, and enterococci. Analyses were performed according to standard water quality methods (APHA, 1998).

Results

Water quality changes were driven by flow conditions and seasonal changes. Fluctuations in temperature, dissolved oxygen, conductivity, and salinity were associated with seasonal changes and low-flow conditions. Changes in pH were often associated with storm events and fluctuations in chlorophyll *a* concentrations. Solids, specifically suspended solids concentrations, exhibited fluctuations primarily with significant storm events (1" or more of rainfall). Fluctuations in nutrient concentrations were commonly associated with application processes and ensuing nutrient runoff after rainfall events. Observed changes in microbial counts during 2002 were due primarily to warmer seasonal temperatures as well as storm events.

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NOTE

*All report tables and figures are labeled according to the DEC watershed number (e.g. "2" for Long watershed, "4" for Hotophia watershed, etc.). The report was formatted as such to facilitate access to certain information for specific watersheds. Because of this, there are no tables and figures with the numbers 3, 5, 6, 7, 10, 11, 12, 14, 15, or 16. The following is a complete list of watershed names and associated DEC numbers.

Otoucalofa 1
Long 2
Hotophia 4
Abiaca 8
Toby Tubby 9
Burney Branch 13
Yalobusha 17

LIST OF FIGURES

G. 2002 mean daily discharge or gauge height for Abiaca Creek, Toby Tubby Creek, Burney Branch Creek, and Yalobusha River. Solid triangles represent sampling dates. Data from USGS, Water Resources (USGS, 2003).

ACKNOWLEDGMENTS

The authors wish to thank Leslie Arbuckle, Chasity Arbuckle, Charles Bryant, Duane Shaw, Trent Peacock, Trent Fivecoat, Jennifer Swint, Joshua Walker, and Toyal Flemons, for technical assistance. Appreciation is also extended to Charles Bryant, Paul Rodrigue and Jennifer Bouldin for reviewing an earlier version of this report. This research was funded in part by the U.S. Army Corps of Engineers, Vicksburt District. Construction of structures for watershed bank stabilization and erosion control was conducted by the U.S. Army Corps of Engineers and USDA Natural Resources Conservation Service.

INTRODUCTION

Deterioration of water quality in river and stream watersheds has been and continues to be a persistent concern throughout the United States, notably in regions with accelerated soil erosion such as the loess hills of northern Mississippi (Cooper and Knight, 1991). Water quality impairment can be attributed to several factors, with sediment contributing the greatest proportion. In addition to sediments, nutrients, pathogens and pesticides are the primary pollutants currently causing impairment in U.S. rivers and streams today. The major source of these pollutants originates from non-point runoff associated with urban and agricultural land-use practices (USEPA, 2000). As a result of severe erosion and incision of streams in the loess hills of northern Mississippi, Congress mandated in 1984 a federal interagency demonstration project on mitigating stream channel erosion (Cooper *et al.*, 1997). Research presented in this report addresses the issue of water quality in north Mississippi streams within the Yazoo Drainage Basin designated through the Demonstration Erosion Control (DEC).

As part of the DEC Project in the Yazoo Drainage Basin, a characterization of current water quality by the Water Quality and Ecological Processes Research Unit at the USDA-ARS National Sedimentation Laboratory was requested by the U.S. Army Corps of Engineers, Vicksburg District. The DEC Project in the Yazoo Drainage Basin is a cooperative interagency project, including the U.S. Army Corps of Engineers, the USDA Natural Resources Conservation Service and the USDA Agricultural Research Service. The projects' primary goals are aimed at flood control, reducing erosion and channel instability with additional goals including demonstration of innovative management techniques, total watershed planning and water quality and environmental enhancement (Cooper and Knight, 1989). Currently, on-going consistent water quality characterization is performed in seven designated watersheds as part of a larger database including habitat, faunal and floral diversity. Additionally, water quality measures are a useful aid in assessing ecosystem health across trophic levels from primary producers (plants and algae) to predatory animals such as fish.

Sediment has been reported as the single most abundant pollutant (by volume) in the Nation's rivers and streams (Fowler and Heady, 1981). The 1996 National Water Quality Inventory stated that about 40% of the nation's surveyed rivers, lakes, and estuaries had water quality impairment, and suspended sediment was the most widespread pollutant impacting surveyed rivers and streams (USEPA, 1997). Sediment-related problems are the most severe in certain regions developed for agriculture. Highly erodible soils in north Mississippi's geological landscape equate to potentially severe problems with sediment transport in streams. Sediment yield from the northern Mississippi hill land streams is about twice the national average, or about 3000 tons per square mile per year (Lizotte *et al.*, 2001). Most streams in this region have experienced accelerated erosion within the last 30 years, often increasing their channel size three to tenfold (Simon and Darby, 1997). Statistics are not available for northern Mississippi alone, but on a statewide basis, 95% of all stream miles do not fully support aquatic life uses, and 91% do not fully support swimming (MDEQ, 1999). These severe conditions produce a situation ideal for research and development of technology for widespread application. Because water is needed to sustain all life, this issue is in critical need of attention. Maintaining water quality assures agriculture a

water supply for crops and livestock. Likewise, it provides a potable supply of drinking water for municipalities. Hence, the quality of life itself hinges on water quality.

The purpose of this report is to characterize and report current water quality conditions during calendar year 2002 in seven north Mississippi loess hill land streams located in the Yazoo Drainage Basin.

MATERIALS AND METHODS

Samples from each of the seven watersheds examined (Fig. 1) were collected and preserved (via ice) twice each month, with the exception of the Toby Tubby Creek, Burney Branch Creek, and Abiaca Creek watersheds, which were collected monthly. General site observations were made and noted at each sample collection. Depth of water and depth to water (recorded from the top of the collection site [bridge rail] to the top of the water's surface), and *in-situ* water chemistry measurements of pH (using calibrated Oakton® waterproof pH testr2 meters), temperature, dissolved oxygen, conductivity, and salinity (using calibrated electronic Yellow Springs Instruments, Inc. model no. 85 water quality meters) were recorded at each site.

One (1) L aqueous samples were transported to the USDA-ARS National Sedimentation Laboratory Water Quality and Ecological Processes Research Unit, Oxford, Mississippi. Physical and chemical water parameters consisting of hardness (EDTA titrametric method), alkalinity (titration method), turbidity (calibrated Hach electronic turbidimeter), total solids, dissolved solids (dried at 180 C), suspended solids (dried at 103-105 C), total ammonium-N (phenate method), total nitrate-N (cadmium reduction method), total nitrite-N (colorimetric method), total nitrogen [NO3-N + NO2-N + total Kjeldahl nitrogen (block digestion and flow injection analysis)], soluble (filterable) phosphorus (ascorbic acid), total phosphorus (persulfate digestion + ascorbic acid), chlorophyll *a*, *b*, *c*, and total (pigment extraction and spectrophotometric determination), fecal coliforms (membrane filter technique), and enterococci (membrane filter technique) were analyzed using standard methods (APHA, 1998).

RESULTS

Otoucalofa Creek

Sampling stations along Otoucalofa Creek are shown in Figure A. Water depth in Otoucalofa Creek was constant throughout the year at nearly all sites, fluctuating with periods of drought and rain (Fig. 1-1, E). Sampling station 1,1, just upstream of Enid Lake (<u>see</u> Fig. A, B), had an increase in winter and spring as reservoir levels increased and decreases in summer and fall (as water levels decreased) due to flood control practices. Otoucalofa Creek water quality measurements of temperature, dissolved oxygen, and conductivity were consistent according to typical seasonal fluctuations (Fig. 1-1). Measurements of pH fluctuated but these fluctuations were due, in part, to seasonal changes (Fig. 1-10), storm events and changes in chlorophyll *a* concentrations (Fig. 1-2). Concentrations of chlorophylls *a*, *b*, and *c*, as well as the sum total chlorophyll, showed typical seasonal fluctuations with peaks in spring and summer (Fig. 1-2, 1-6, 1-7). Solids (total, dissolved, suspended) and turbidity remained fairly constant, with a noticeable peak occurring on 3/18/2002, corresponding with rainfall

events on 3/15/02, 3/16/02, and 3/17/02 totaling 3.2 inches and a second consecutive peak on 4/2/02 corresponding with rainfall on 3/30/02 and 3/31/02 totaling 2.9 inches (Fig.1-2, 1-3, E). Hardness and alkalinity measurements were indicative of "soft" water and typical for stream waters flowing through a region with limited calciferous geologic formations (Fig. 1-3). Filterable and total phosphorus concentrations remained generally constant over the year, with the occasional peak coinciding with storm events (Fig. 1-4, E). Ammonium-N, nitrate-N, nitrite-N, and total nitrogen concentrations followed similar patterns with peaks associated with storm events and/or animal remains at or near the sampling locality (Fig. 1-4, 1-5, E). Site 1,1 (Fig. B) had consistently greater nutrient concentrations and associated chlorophyll *a* concentrations due to its location just downstream of the outfall of a wastewater treatment facility serving the city of Water Valley (Fig. 1-2, 1-4, 1-5, 1-6, 1-7). Fecal coliform measurements showed two sampling sites (1,6 and 1,4) experienced separate peaks on 8/20/02 and 12/10/02, respectively, during low-flow conditions (Fig. 1-5). Enterococci measurements exhibited several peaks 4/30/02, 8/20/02, 10/15/02, and 12/10/02 during low-flow conditions. A peak observed on 5/28/02 coincided with a storm event from 5/27/02 to 5/28/02 totaling 1.8 inches of rain (Fig. 1-5).

Examination of long-term data (18 years) of chlorophyll *a* values showed no significant increasing or decreasing trends in Otoucalofa Creek (Fig. 1-8, 1-9). Long-term measurements of this parameter appeared relatively stable with most peaks occurring during rapid population growth in warmer periods followed by periods of population decline and cooler water temperatures. Most major peaks occurring during 1994-1995 and again in 1998 coincided with rainfalls of approximately 0.5 inches or more.

Long Creek

Locations of sampling sites for Long Creek are presented in Figure A. Water depth remained relatively constant with minor peaks occurring on 3/18/02, 5/28/02, and 11/12/02 coinciding with rainfall of at least 0.5 inches (Fig 2-1, E). As with Otoucalofa Creek, measurements of temperature, dissolved oxygen, and conductivity in Long Creek were consistent with typical seasonal fluctuations (Fig 2-1). Measurements of pH fluctuated but these fluctuations were due, in part, to seasonal changes (Fig. 2-8), storm events, and changes in chlorophyll *a* concentrations (Fig. 2-2). Concentrations of chlorophylls *a*, *b*, and *c* as well as the sum total chlorophyll showed typical seasonal fluctuations with peaks in spring, summer, and again in late fall (Fig. 2-2, 2-6, 2-7). Turbidity and solids concentrations (total, dissolved, suspended) were relatively constant with peaks occurring on 3/18/02 and 5/28/02 in association with storm events (>0.5 inches of rainfall) and increased stream flow (Fig. 2-2, 2-3, E). Hardness and alkalinity measurements were indicative of "soft" water and typical for stream waters flowing through a region with limited calciferous geologic formations (Fig. 2-3). Phosphorus concentrations (filterable and total) showed minor fluctuations throughout the year with peaks occurring in conjunction with nutrient applications and ensuing runoff during storm events (Fig 2-4, E). Ammonium-N, nitrate-N, nitrite-N, and total nitrogen concentrations also fluctuated throughout calendar year 2002 (Fig. 2-4, 2-5) with peaks often associated with rainfall events (Fig. E), nutrient applications and ensuing runoff, or animal remains. Fecal coliforms had peaks in colony counts at all

sites on 1/8/02 and 5/28/02 in association with winter and spring rainfall events (>0.5 inches; Fig. E) whereas peaks occurring on 3/5/02, 8/20/02, and 10/15/02 were localized events at a few sites (Fig. 2-5). Colony counts of enterococci exhibited fluctuations throughout calendar year 2002 with peaks at all sites occurring on 1/8/02 and 5/28/02 (Fig. 2-5) in conjunction with winter and spring storm events (>0.5 inches of rainfall; Fig. E). As with fecal coliforms, remaining peaks of enterococci were localized events at a few sites.

Hotophia Creek

Hotophia Creek sampling localities are presented in Figure A. Water depth exhibited similar fluctuations as Long Creek due to the close proximity of these watersheds (Fig. 4-1, 2-1, A). Depth measurements remained relatively constant with a minor peak occurring at all three sites on 3/18/02 (Fig. 4-1) in association with a storm event from 3/16/02 to 3/17/02 (1.17 inches of rainfall; Fig. E). As discussed earlier (in Otoucalofa and Long creeks), temperature, dissolved oxygen, and conductivity measurements exhibited typical seasonal fluctuations (Fig. 4-1). Measurements of pH fluctuated with seasonal changes (Fig. 4-7), storm events (Fig. E), and changes in chlorophyll *a* concentrations (Fig. 4-2, 4-6). Concentrations of chlorophylls *a*, *b*, and *c* as well as the sum total chlorophyll exhibited typical seasonal fluctuations with peaks in spring, summer, and late fall (Fig. 4-2, 4-6). Turbidity and solids (total, dissolved, and suspended) measurements exhibited fluctuations throughout 2002 with decreases occurring during periods of low stream flow and peaks associated with rainfall events (Fig. E) and increases in stream flow (Fig. 4-2, 4-3). As expected, hardness and alkalinity measurements in Hotophia Creek were indicative of “soft” water and typical for stream waters flowing through a region with limited calciferous geologic formations (Fig. 4-3). Phosphorus concentrations (filterable and total) were relatively constant with minor fluctuations throughout calendar year 2002 (Fig. 4-4). Greatest fluctuations occurred at site 4,3 on 1/22/02 and 7/9/02 for filterable phosphorus and 7/23/02 and 8/20/02 for total phosphorus (Fig. 4-4). As with Long Creek, ammonium-N, nitrate-N, nitrite-N, and total nitrogen concentrations in Hotophia Creek also fluctuated throughout calendar year 2002 (Fig. 2-4, 2-5, 4-4, 4-5) with peaks often associated with rainfall events (Fig. E), nutrient applications and ensuing runoff, or animal remains. Fecal coliforms had peaks in colony counts at all sites on 1/8/02 in association with a rainfall event (>0.5 inches; Fig. E) during the wet season, whereas a significant peak occurring on 8/20/02 was a localized event at site 4,3 (Fig. 4-5). Colony counts of enterococci exhibited fluctuations throughout calendar year 2002 with peaks at all sites occurring on 1/8/02 and 12/10/02 (Fig. 4-6) in conjunction with wet season storm events (Fig. E). As with fecal coliforms, remaining peaks of enterococci were localized events at a few sites (Fig. 4-5).

Abiaca Creek

Sampling stations for Abiaca Creek are shown in Figure A. As with other DEC watersheds, water depth in Abiaca Creek was relatively constant throughout the year with a minor peak observed on 4/2/03 (Fig. 8-1) coinciding with recent rainfall events (3/30/02 to 3/31/02) and increased stream flow (Fig. E, G). As exhibited in other DEC

watersheds, temperature, dissolved oxygen, and conductivity showed typical seasonal fluctuations throughout calendar year 2002 (Fig. 8-1). Measurements of pH were relatively stable during 2002 but decreased slightly at all sites on 11/12/02 after a storm event (Fig. E) and decreases in chlorophyll *a* concentrations (Fig. 8-2, 8-6, 8-7). This parameter also showed relatively limited seasonal fluctuations (Fig. 8-8) compared to other DEC watersheds. Concentrations of chlorophylls *a*, *b*, and *c* as well as the sum total chlorophyll showed typical seasonal fluctuations with peaks in spring and summer (Fig. 8-2, 8-6, 8-7). Turbidity and solids (total, dissolved, and suspended) measurements exhibited fluctuations throughout calendar year 2002 with decreases occurring during periods of low stream flow (Fig. G) and peaks associated with rainfall events (Fig. E) and increases in stream flow (Fig. 8-2, 8-3, G). An isolated peak occurring on 6/25/02 was a localized storm event affecting only sites 8,1 and 8,2 (Fig. 8-2, 8-3). Measurements of hardness and alkalinity in Abiaca Creek were comparable to other streams within the Yazoo drainage basin and indicative of "soft" water typical of the region (Fig. 8-3). Within Abiaca Creek, filterable and total phosphorus concentrations were generally constant during 2002, with peaks at all sites coinciding with rainfall events and increased stream flow (Fig. 8-4, E, G). Again, an isolated peak in phosphorus concentrations at sites 8,1 and 8,2 was observed on 6/25/03 and was due to a localized storm event and ensuing increases in stream flow, solids and turbidity (Fig. 8-3, 8-4, E, G). Ammonium-N, nitrate-N, nitrite-N, and total nitrogen concentrations in Abiaca Creek also fluctuated throughout calendar year 2002 (Fig. 8-4, 8-5) with peaks often associated with rainfall events (Fig. E), increases in stream flow (Fig. G), nutrient applications and ensuing runoff, or animal remains. Fecal coliforms exhibited a peak in colony counts at all sites on 4/2/02 in association with a rainfall event (>0.5 inches; Fig. E) and increased stream flow (Fig. G) whereas significant peaks occurring on 6/25/02 at sites 8,1 and 8,2 and 8/20/02 at sites 8,1, 8,3, 8,6, and 8,8 were localized events (Fig. 8-5). Colony counts of enterococci exhibited fluctuations throughout calendar year 2002 with a peak at all sites occurring on 4/2/02 (Fig. 8-5) in conjunction with a storm event (Fig. E) and increased stream flow (Fig. G). As with fecal coliforms, remaining peaks of enterococci were localized events at a few sites (Fig. 8-5).

Toby Tubby Creek

Sampling stations along Toby Tubby Creek are presented in Figure A. Water depth in Toby Tubby Creek was relatively constant throughout calendar year 2002 with minor peaks occurring on 1/22/02, 3/18/02, and 10/29/02 (Fig. 9-1). These fluctuations were associated with recent rainfall events and increases in stream flow (Fig. F, G). *In-situ* water quality measurements of temperature, dissolved oxygen, and conductivity exhibited typical seasonal fluctuations (Fig. 9-1). Measurements of pH fluctuated due, in part, to seasonal changes (Fig. 9-7), storm events and changes in chlorophyll *a* concentrations (Fig. 9-2, 9-6, F). Concentrations of chlorophylls *a*, *b*, and *c* as well as the sum total chlorophyll showed typical seasonal fluctuations with peaks in spring, summer, and fall (Fig. 9-2, 9-6). Measurements of turbidity and solids (total, dissolved and suspended) were relatively constant with minor peaks occurring at all sites on 1/22/02, 3/18/02, 5/14/02, and 7/9/02 coinciding with rainfall events and associated increases in stream flow (Fig. 9-2, 9-3, F, G). An isolated peak observed at site 9,3

(Fig. A, C) on 10/29/02 coincides with a peak in chlorophyll *a* concentration illustrating that this increase is due, in part, to algae and not exclusively sediment. Hardness and alkalinity measurements in Toby Tubby Creek shared a similar pattern with other DEC streams in the Yazoo drainage basin that indicate “soft” water flowing through the north Mississippi loess hills, a region of limited calciferous geologic formations (Fig. 9-3). Filterable and total phosphorus concentrations in Toby Tubby Creek remained generally constant over calendar year 2002, with occasional peaks coinciding with storm events and associated increases in stream flow (Fig. 9-4, F, G). An isolated peak in total phosphorus observed at site 9,3 (Fig. A, C) on 10/29/02 coincides with a peak in chlorophyll *a* concentration showing that this increase is due, in part, to algae and not exclusively sediment. Concentrations of ammonium-N, nitrate-N, nitrite-N, and total nitrogen within Toby Tubby Creek fluctuated throughout 2002 (Fig. 9-4, 9-5) due, in part, to rainfall events (Fig. E), increases in stream flow (Fig. G), nutrient applications and ensuing runoff, or animal remains. Fecal coliform measurements showed three peaks occurring on 5/14/2002, 7/9/2002, and 10/1/02 during recent storm events and increased stream flow conditions (Fig. 9-5, F, G). Enterococci colony counts in Toby Tubby Creek fluctuated during 2002 with peaks occurring on the same dates as peaks in fecal coliform counts (Fig. 9-5).

Burney Branch Creek

Locations of Burney Brach Creek sampling sites are presented in Figure A. Similar to other DEC watersheds, Burney Branch Creek water depth remained relatively constant throughout calendar year 2002 with minor peaks occurring on 3/18/02 and 10/29/02 in conjunction with recent storm events and associated increases in stream flow (Fig. 13-1, F, G). Several *in-situ* water quality measurements of temperature, dissolved oxygen, and conductivity revealed typical seasonal fluctuations (Fig. 13-1). Site 13,3 (Fig. A, D) frequently showed greater conductivity and dissolved solids measurements than sites 13,1 and 13,2 due to the site's close proximity just downstream of a wastewater treatment facility serving the University of Mississippi in Oxford, Mississippi (Fig. 13-1, 13-3). Measurements of pH in Burney Branch Creek fluctuated due, in part, to seasonal fluctuations (Fig. 13-7), storm events, and changes in chlorophyll *a* concentrations (Fig. 13-2, 13-6, F). Concentrations of chlorophylls *a*, *b*, and *c* as well as the sum total chlorophyll showed typical seasonal fluctuations with peaks in spring, summer, and fall (Fig. 13-2, 13-6). Turbidity and remaining solids (total and suspended) measurements were relatively constant with a significant peak occurring at all sites on 10/29/02 coinciding with a storm event and associated increase in stream flow (Fig. 13-2, 13-3, F, G). An isolated peak occurred at site 13,3 (Fig. D) on 1/22/02 due, in part, to recent construction and land development near this site (Fig. 13-3). Hardness and alkalinity measurements in Burney Branch Creek showed similar patterns with other DEC streams in the Yazoo drainage basin that indicate “soft” water flowing through the north Mississippi loess hills, a region of limited calciferous geologic formations (Fig. 13-3). Burney Branch Creek phosphorus (filterable and total) measurements remained relatively constant throughout 2002 (Fig. 13-4). Phosphorus concentrations were consistently much greater at site 13,3 (Fig. D), again due to its location just downstream of the University of Mississippi wastewater treatment facility outfall (Fig. 13-4). An isolated total phosphorus peak occurred at site 13,3 (Fig. D) on

1/22/02 due, in part, to increases in suspended sediments from recent construction and land development near this site (Fig. 13-3, 13-4). Concentrations of various nitrogen species (ammonium-N, nitrate-N, nitrite-N, and total nitrogen) measured at sites 13,1 and 13,2 fluctuated throughout calendar year 2002 (Fig. 13-4, 13-5). These fluctuating patterns are not as closely associated with rainfall or stream flow as other water quality parameters due, in part, to urban nutrient applications. Both phosphorus and nitrogen were greater at site 13,3 (Fig. A, D) than other sites, again, due to its location adjacent to a wastewater treatment facility outfall (Fig. 13-4, 13-5). Microbial analyses revealed fluctuations in fecal coliform and enterococci contamination with greater peaks occurring at sites 13,2 and 13,3 that are located closer to Oxford, Mississippi, than site 13,1 (Fig. 13-5, A). Patterns in fluctuations showed little association with rainfall or stream flow (Fig. 13-5, F, G).

Yalobusha River

Figure A shows the locations for sampling sites along the Yalobusha River. Water depth in this DEC watershed remained relatively constant throughout 2002 with peaks observed on 3/18/02 and 10/29/02 in conjunction with rainfall events and increases in stream flow (Fig. 17-1, F, G). Yalobusha River *in-situ* water quality measurements of temperature, dissolved oxygen, and conductivity were consistent with typical seasonal fluctuations (Fig 17-1). Measurements of pH fluctuated throughout calendar year 2002 due, in part, to changes in chlorophyll *a* concentrations, storm events, and (to a lesser extent) seasonality within the watershed (Fig. 17-2, 17-6, 17-7, 17-8, 17-9, 17-10, F). Concentrations of chlorophylls *a*, *b*, and *c* as well as the sum total chlorophyll showed typical seasonal fluctuations with peaks in spring, summer, and fall (Fig. 17-2, 17-6, 17-7, 17-8, 17-9). A significant peak in chlorophyll *a* occurred at all sites on 9/3/02 and was due, in part, to dry, low flow conditions, and seasonally appropriate conditions for rapid algal growth (Fig. 17-2, 17-6, 17-7, 17-8, 17-9, F, G). Turbidity and solids concentrations (total, dissolved, suspended) in Yalobusha River were relatively constant with peaks occurring on 1/8/02, 3/18/02, 6/11/02, 6/25/02, 7/23/02, 9/17/02, and 10/29/02 in association with storm events (>0.5 inches of rainfall) and increases in stream flow (Fig. 17-2, 17-3, F, G). Yalobusha River hardness and alkalinity measurements were " soft" and comparable to other DEC streams (Fig. 17-3). Filterable and total phosphorus concentrations within the watershed exhibited fluctuations during 2002 with peaks occurring primarily during storm events, ensuing increases in stream flow, turbidity, suspended solids concentrations, and nutrient applications (Fig. 17-2, 17-3, 17-4, F, G). Ammonium-N, nitrate-N, nitrite-N and total nitrogen measurements were relatively constant during calendar year 2002 with significant peaks occurring during spring and summer (Fig. 17-4, 17-5). These nutrient peaks were not as closely associated with rainfall and stream flow, as were other water quality parameters and could be associated with nutrient applications or decomposition of refuse and/or animal remains (Fig. 17-4, 17-5, F, G). Microbial analyses of the Yalobusha River revealed fluctuations in both fecal coliform and enterococci contamination coinciding with rainfall events and associated increases in stream flow (Fig. 17-5, F, G).

SUMMARY

Twenty-two water quality parameters were measured for watersheds of seven hill land streams and rivers in the Yazoo drainage basin during 2002. Expected patterns in yearly fluctuations of temperature, dissolved oxygen, conductivity, and salinity were associated with typical seasonal changes. Fluctuations in pH measurements were primarily associated with rainfall events and similar fluctuations in chlorophyll *a* concentrations. Turbidity and solids, specifically suspended solids, measurements exhibited fluctuations coinciding with storm events and ensuing increases in runoff and stream flow. Hardness and alkalinity within the Yazoo drainage basin were indicative of “soft” water flowing through the north Mississippi loess hills, a region with limited calciferous geologic formations. Patterns of filterable phosphorus concentrations were commonly associated with nutrient applications and sediment-laden runoff during storm events. Total phosphorus concentrations typically fluctuated in conjunction with turbidity and suspended solids due to storm events and associated increases in stream flow. Patterns of measured nitrogen species (ammonia, nitrate, nitrite, and total nitrogen) were not as closely associated with storm events and increased stream flow as other water quality parameters (*e.g.* turbidity, suspended solids, total phosphorus). Nitrogen measurements were influenced by other factors such as nutrient applications or decomposition of refuse and/or animal remains at, or near, sampling stations. Individual sites within specific watersheds (*e.g.* Otoucalofa Creek site 1,1 and Burney Branch Creek site 13,3) in close proximity to wastewater treatment facilities in urbanized areas, exhibited significantly elevated nutrient concentrations above ambient conditions. Observed changes in microbial contamination during calendar year 2002 were due primarily to storm events and increases in stream flow.

Monitoring chlorophyll *a* concentrations as an indirect measure of algal biomass and, hence, primary production, in aquatic ecosystems is a valuable element in assessing the ecological health of a watershed. Primary producers, such as phytoplankton and periphytic algae, influence the systems by providing a food source for herbivores and, indirectly, predators (trophic interactions), altering light attenuation and penetration, and affecting physico-chemical parameters such as dissolved oxygen concentrations and pH (Allen, 1995). Algae, in turn, are influenced by nutrient concentrations, light intensity, and sedimentation and can be used as an indirect measure of habitat degradation. Nuisance levels of algae (algal blooms) due to excessive nutrient loading and/or increased light levels from canopy loss can cause dissolved oxygen depletion or release toxins leading to fish kills (Abel, 2000). Severely limited levels of algae from excessive suspended sediments can also limit animal diversity (Allen, 1995). These factors illustrate the importance of measuring chlorophyll *a* concentrations in rivers and streams and its use as an integral part of the water quality monitoring process.

Overall evaluation of water quality data during calendar year 2002 was performed in the seven hill land watersheds of the Yazoo drainage basin as part of a larger database including habitat, fisheries, benthic invertebrate populations and plant diversity. Specific studies and experiments such as the current aspect of water quality data characterization are useful in assessing stream system stability and restoration success. Results of the current monitoring year show watershed stability, since most north Mississippi hill land streams depend on shallow groundwater seepage for base

flow. However, caution should be exercised, since the use of data from a single year is considered preliminary and should be evaluated in light of long-term watershed changes.

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Figure A. Map of Demonstration Erosion Control (DEC) project watersheds and sampling locations for each watershed during 2002. See Note within text for an explanation of watershed identification numbers.

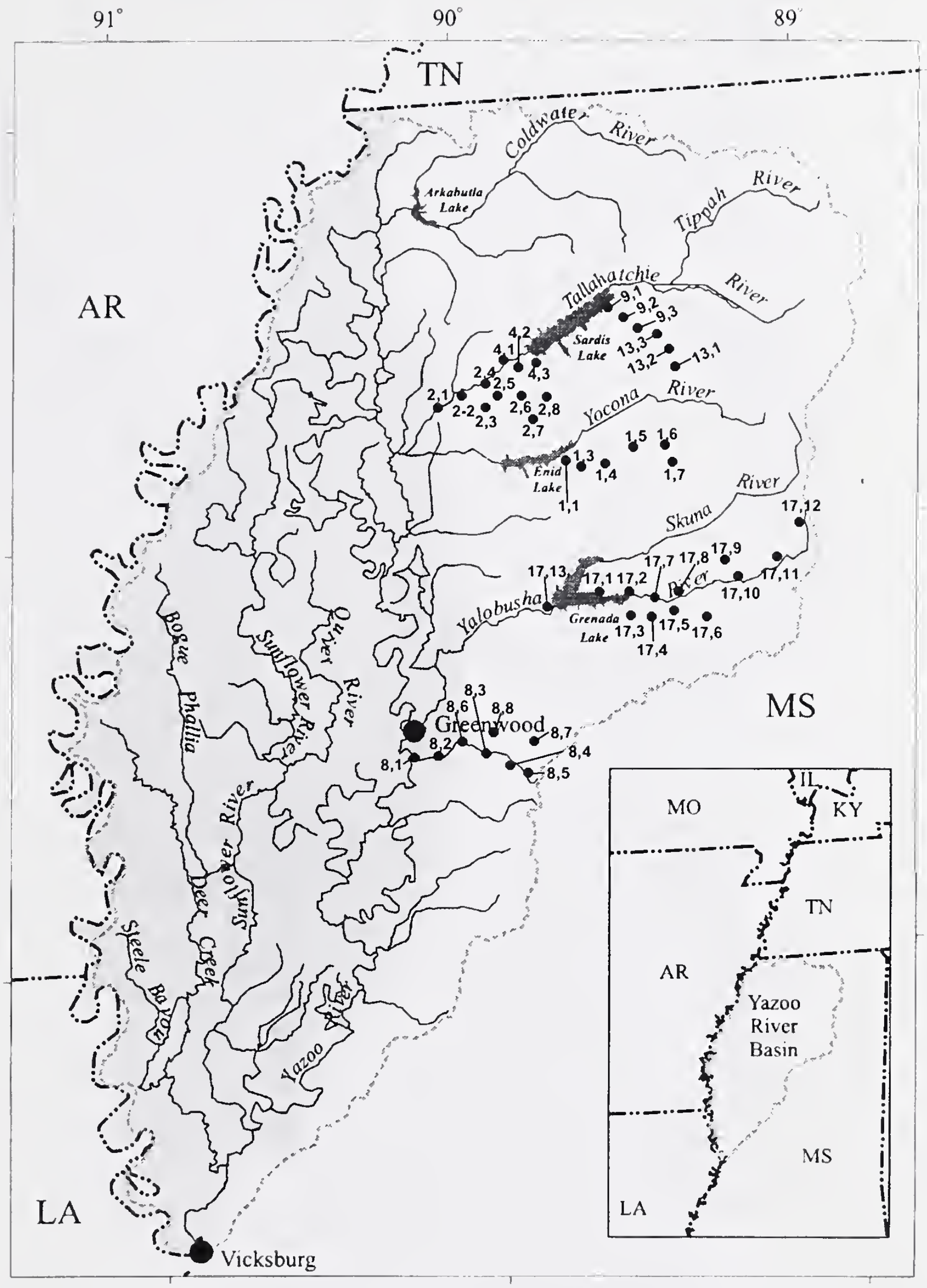


Fig. 1-1. 2002 water depth, temperature, dissolved oxygen, and conductivity measurements for Otoucalofa Creek.

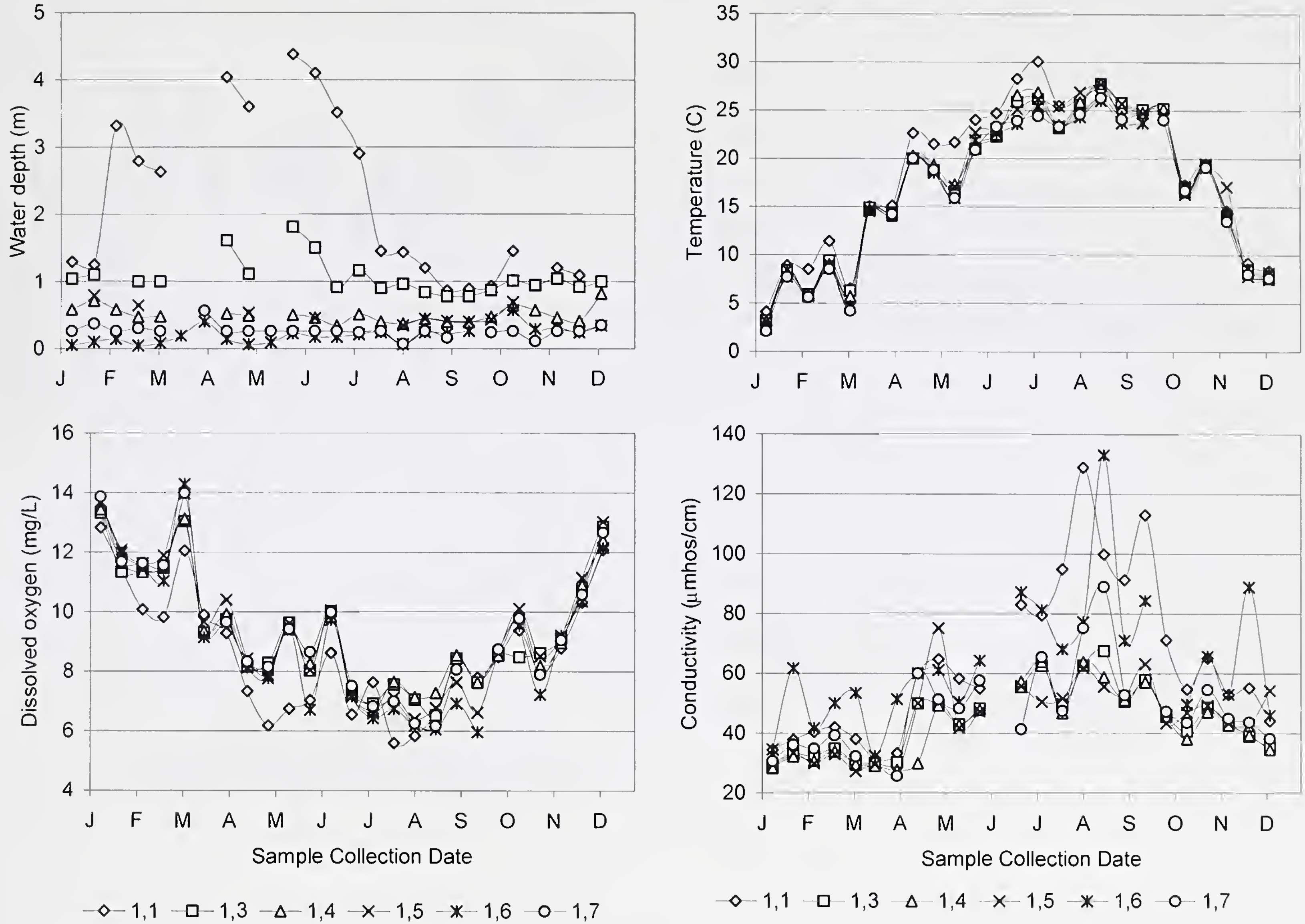


Fig. 1-2. 2002 pH, and chlorophyll *a*, turbidity, and total solids measurements for Otoucalofa Creek.

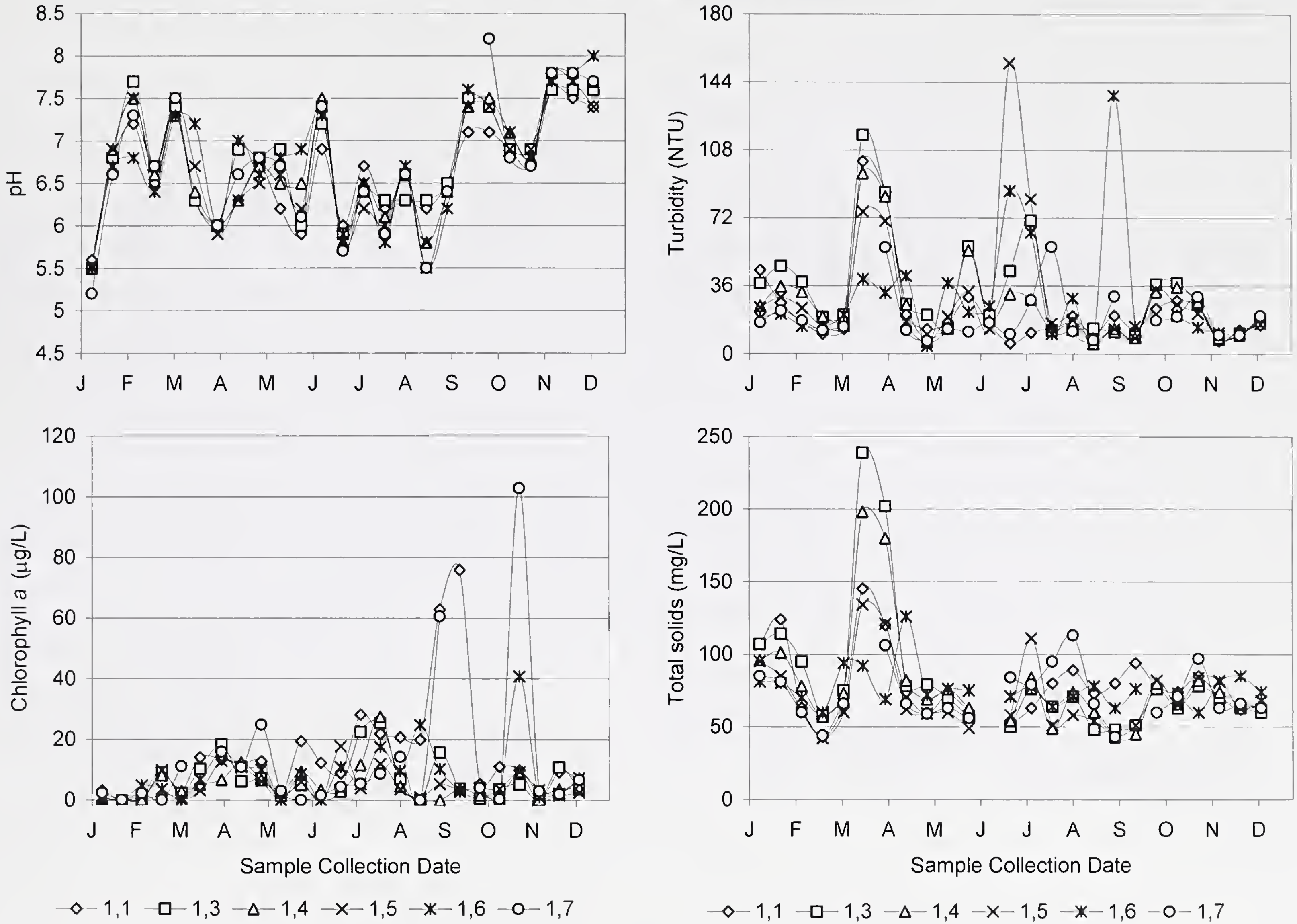


Fig. 1-3. 2002 dissolved and suspended solids, hardness, and alkalinity measurements for Otoucalofa Creek.

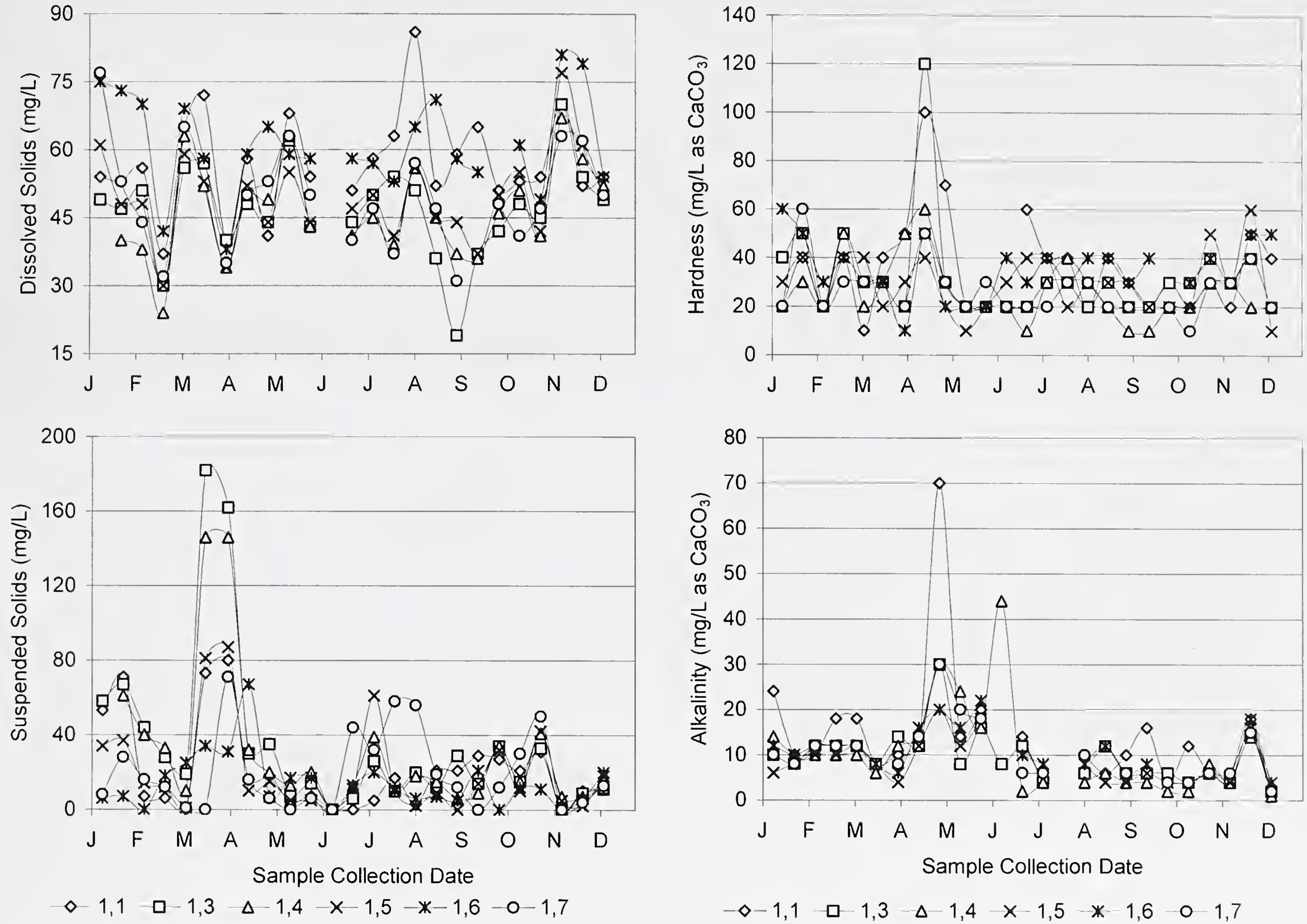


Fig. 1-4. 2002 filtered phosphorus, total phosphorus, ammonium-N, and nitrate-N measurements for Otoucalofa Creek.

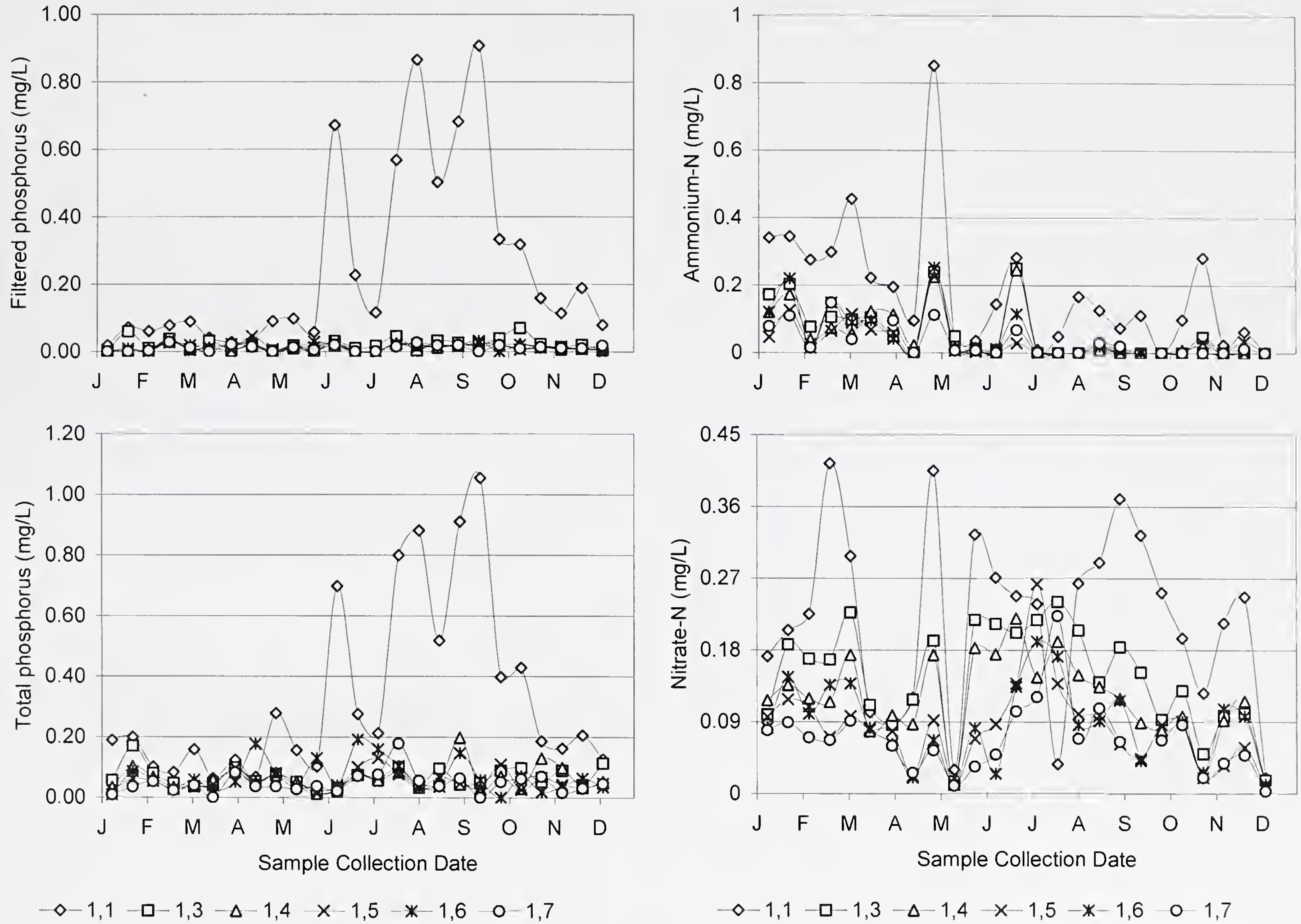


Fig. 1-5. 2002 nitrite-N, total nitrogen, fecal coliform and enterococci measurements for Otoucalofa Creek.

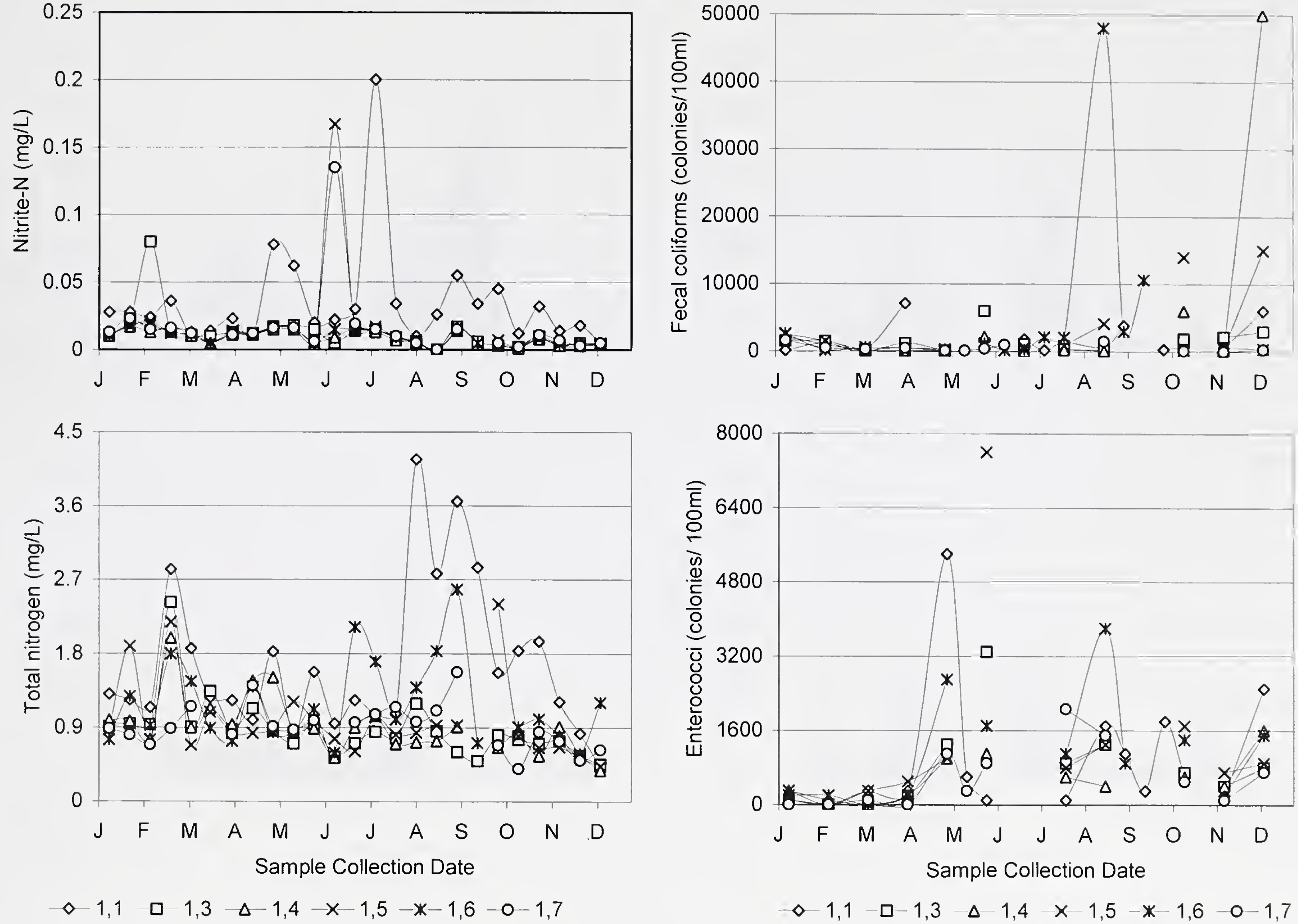


Fig. 1-6. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Otoucalofa Creek sites 1,1, 1,3, 1,4, and 1,5.

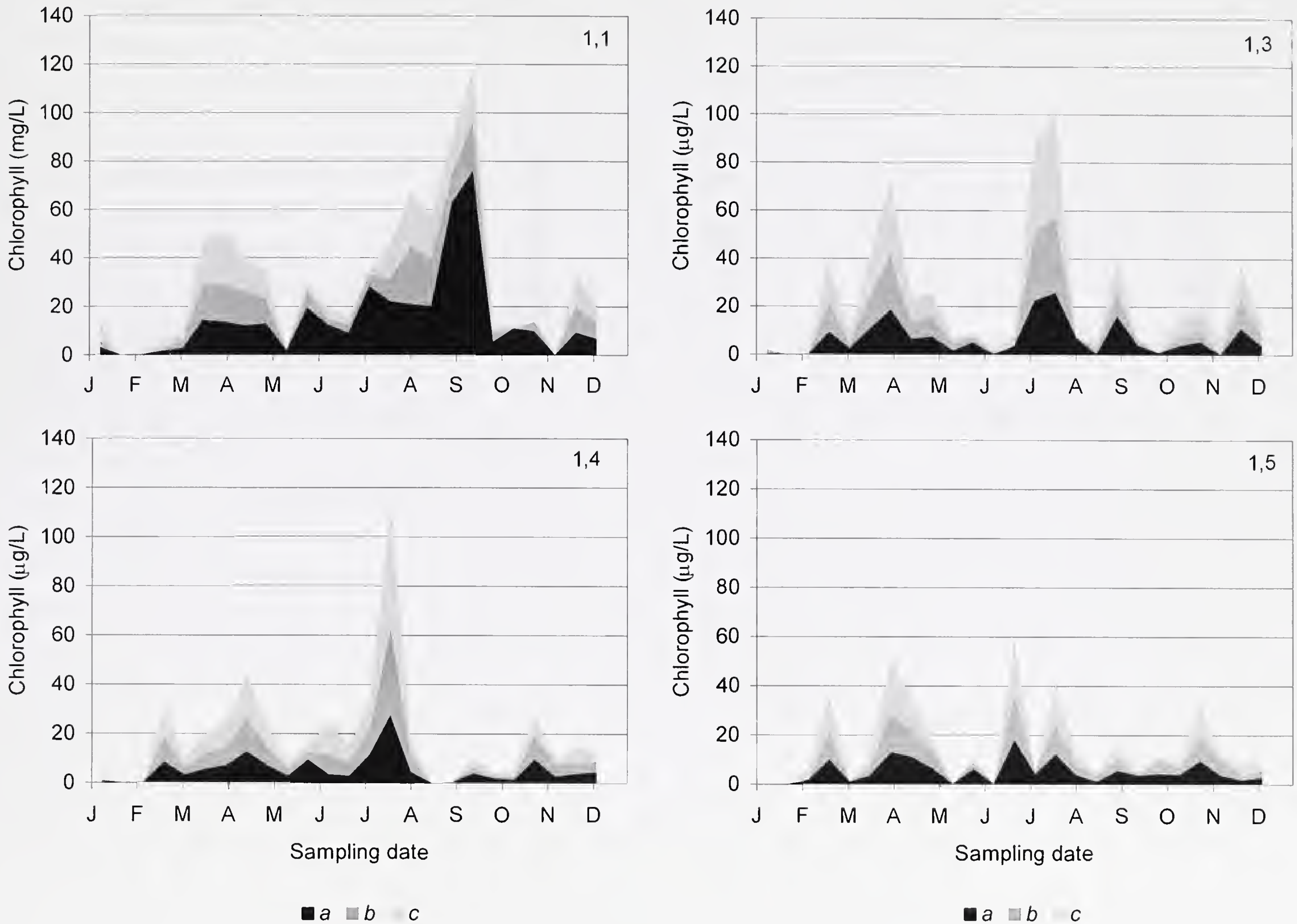


Fig. 1-7. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Otoucalofa Creek sites 1,6 and 1,7.

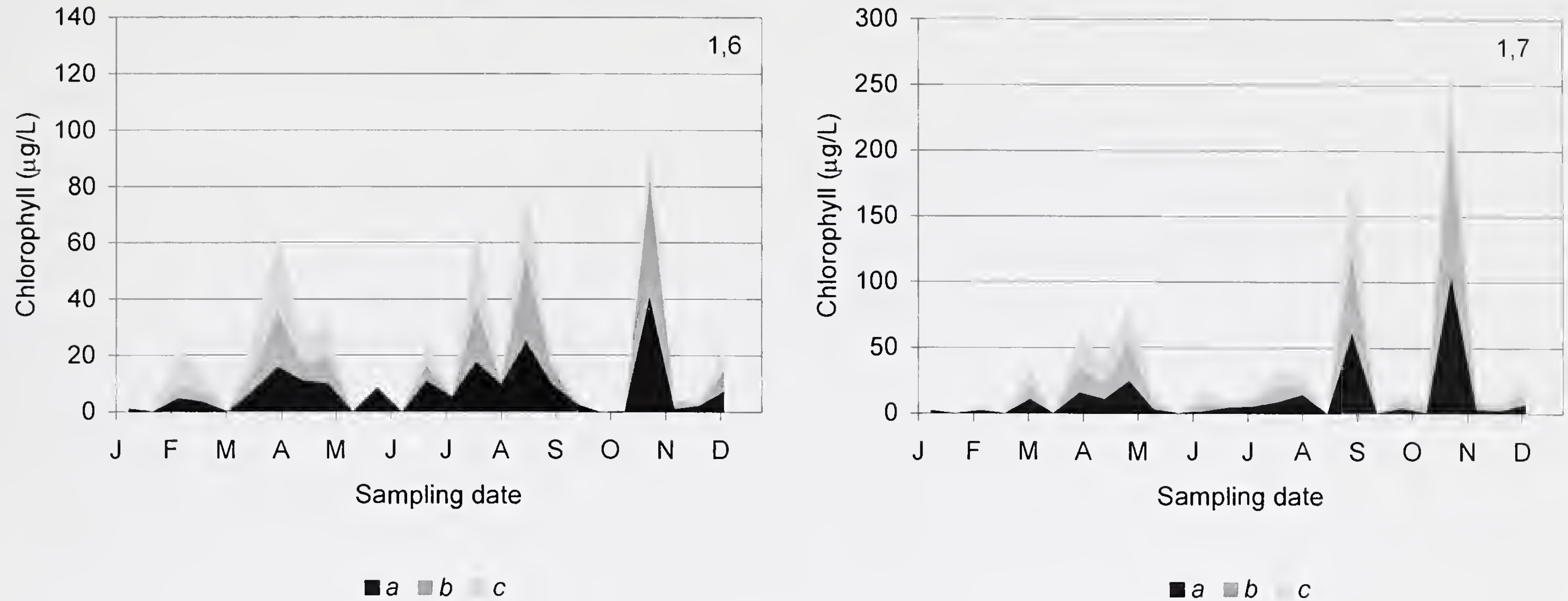


Fig. 1-8. Chlorophyll *a* measurements for Otoucalofa Creek sites 1,1, 1,3, 1,4 and 1,5 from 1985-2002.

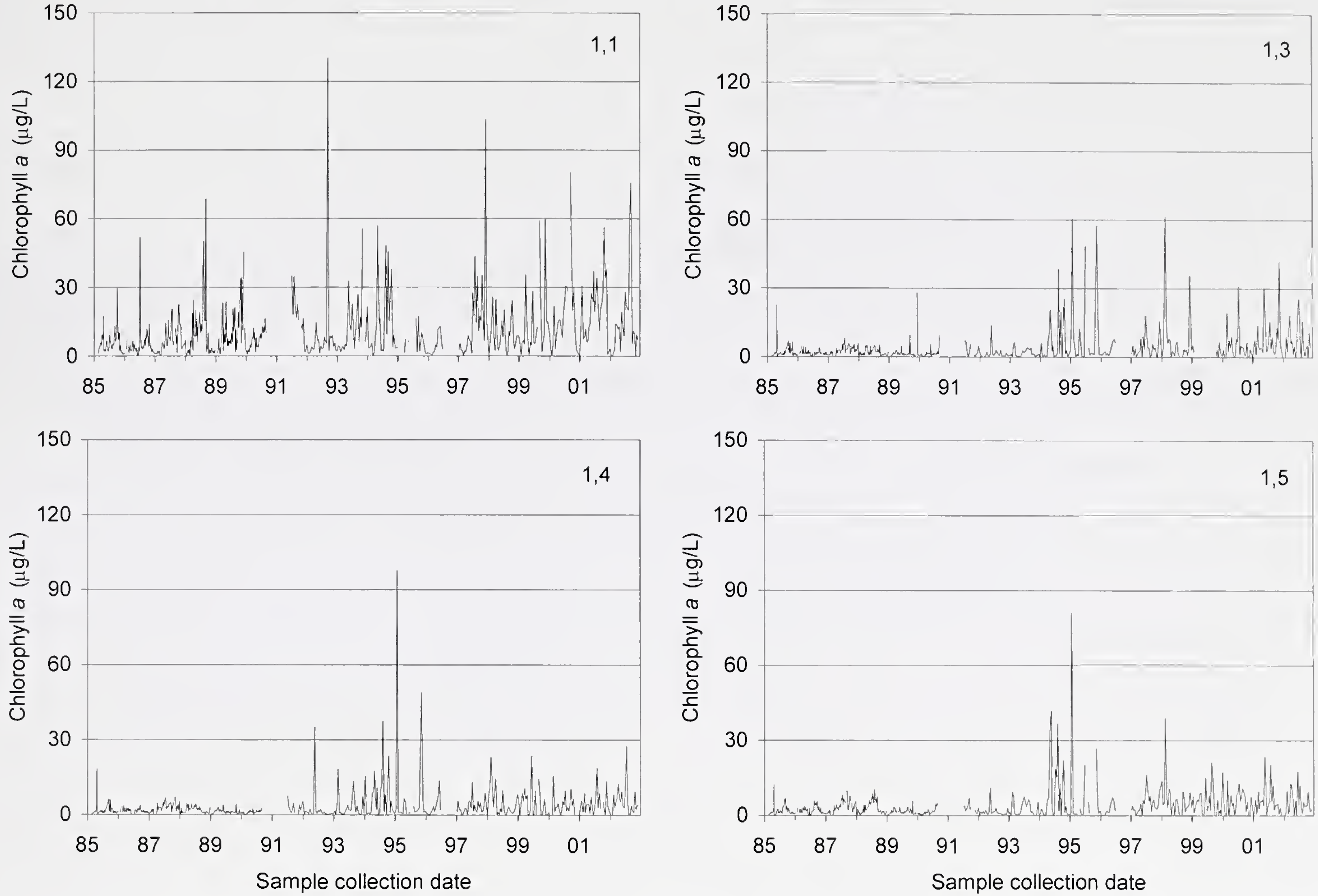


Fig. 1-9. Chlorophyll *a* measurements for Otoucalofa Creek sites 1,6 and 1,7 from 1985-2002.

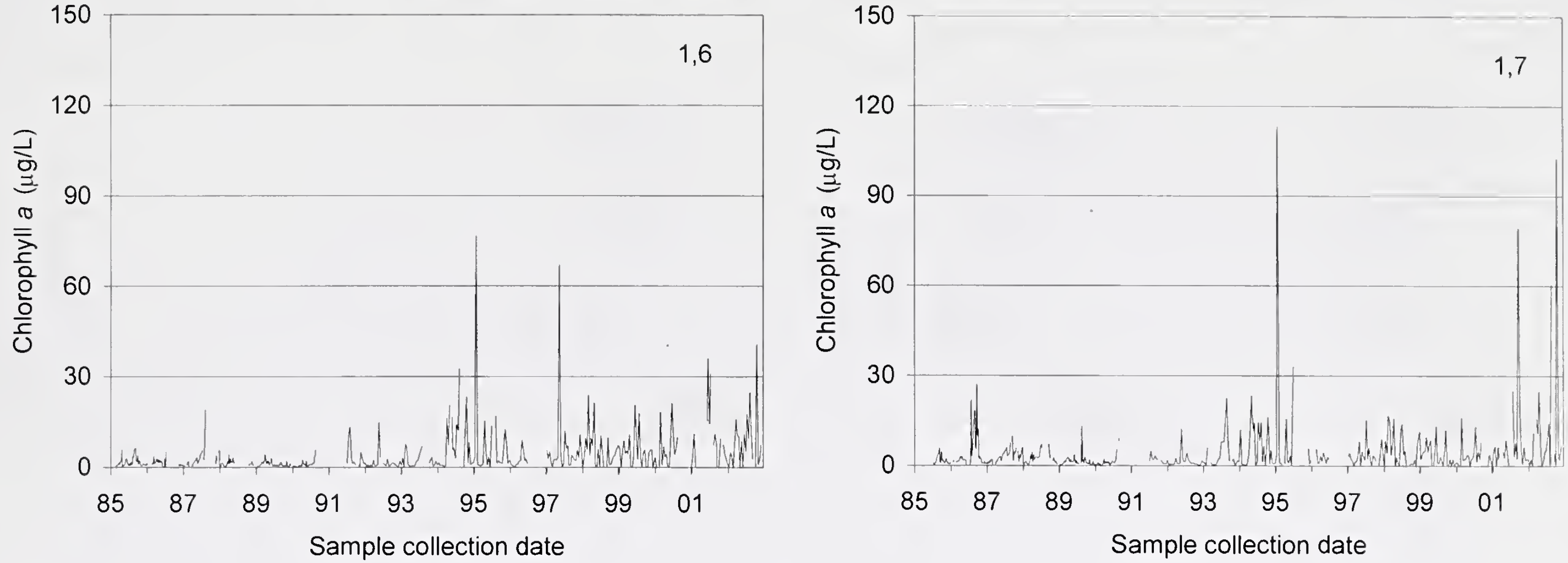


Fig. 1-10. 2002 seasonal pH measurements for Otoucalofa Creek.

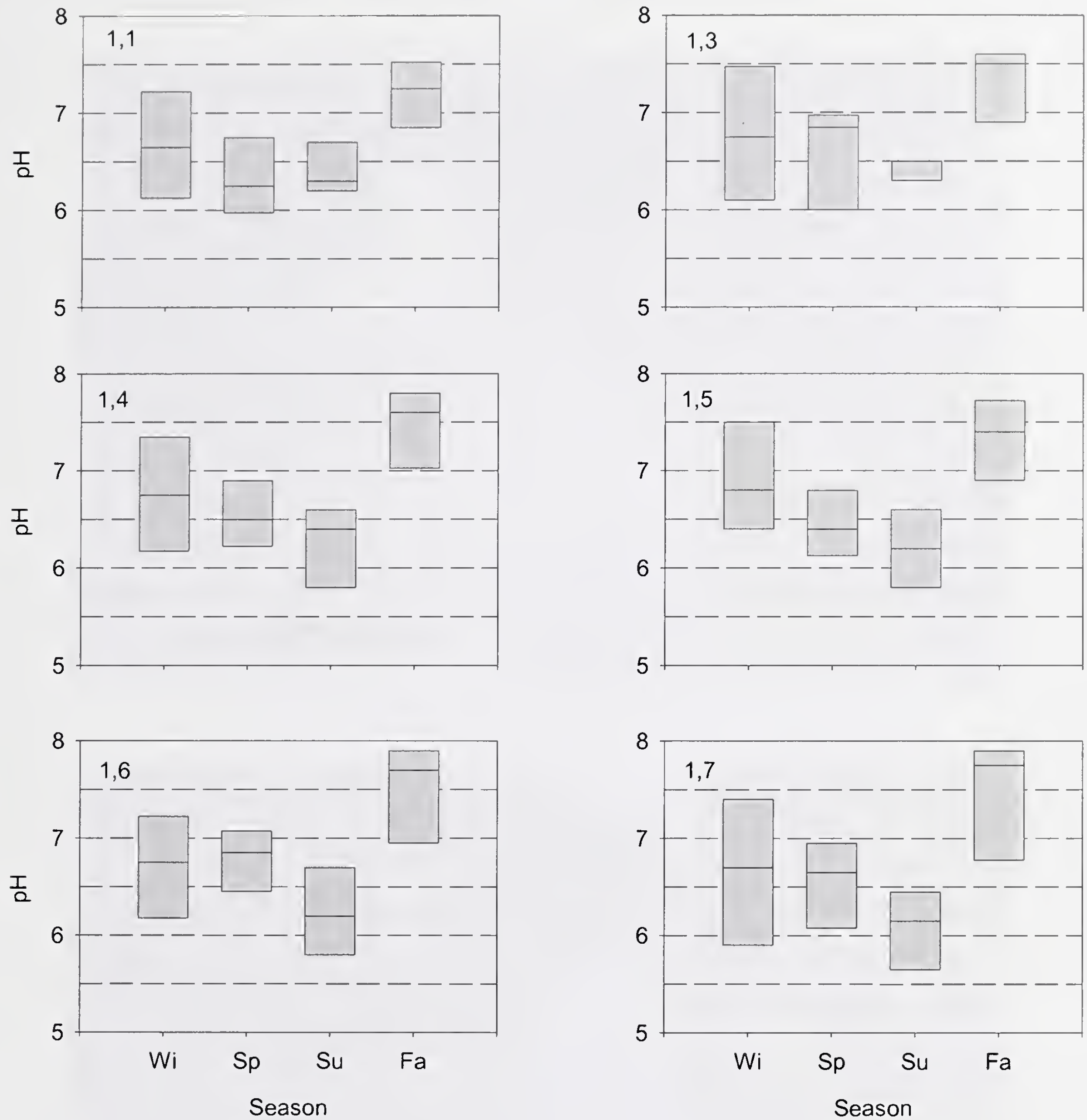


Figure B. Otoucalofa Creek site 1,1 (A) upstream and (B) downstream.

A

B

Fig. 2-1. 2002 water depth, temperature, dissolved oxygen, and conductivity measurements for Long Creek.

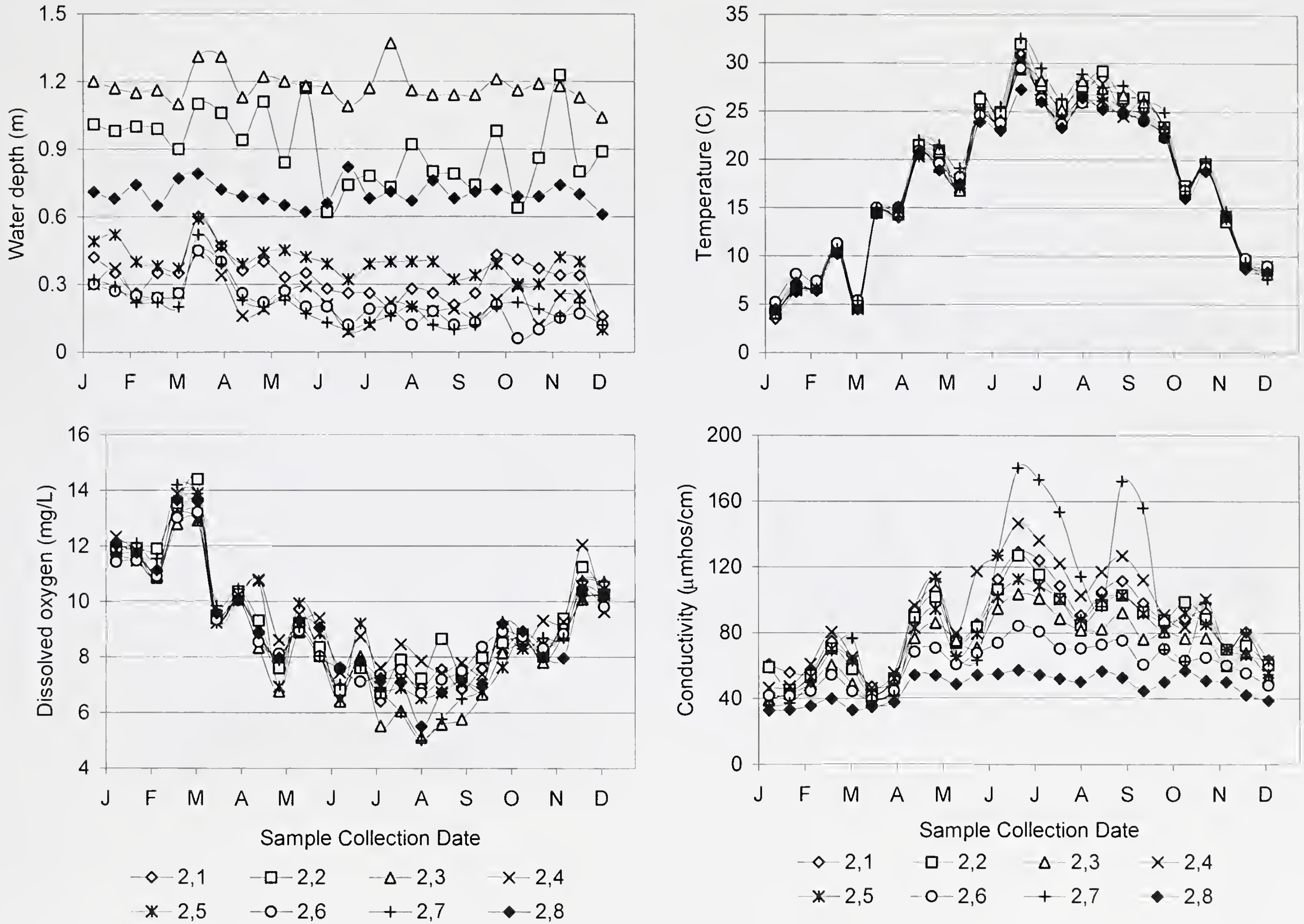


Fig. 2-2. 2002 pH, chlorophyll *a*, turbidity, and total solids measurements for Long Creek.

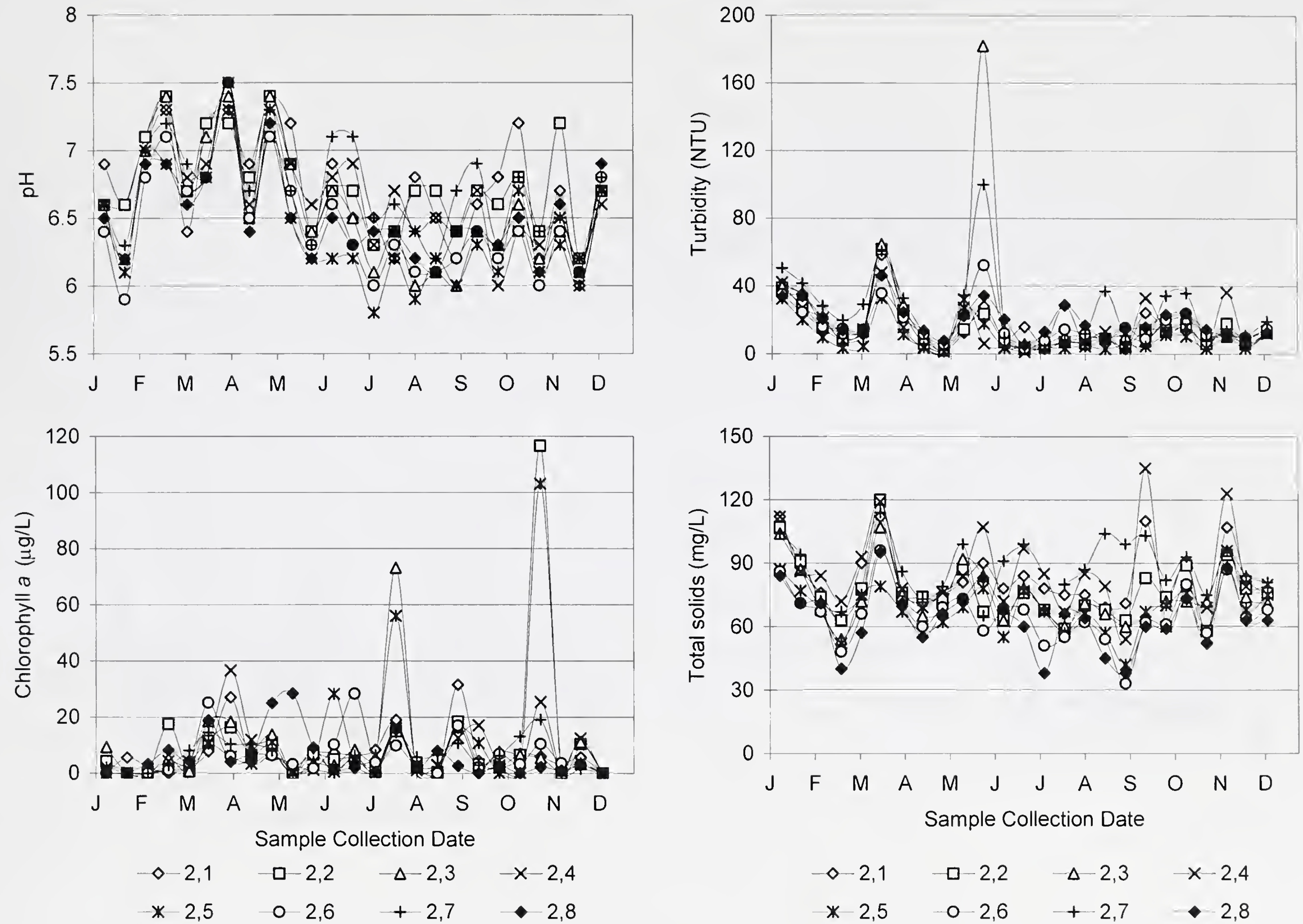


Fig. 2-3. 2002 dissolved and suspended solids, hardness, and alkalinity measurements for Long Creek.

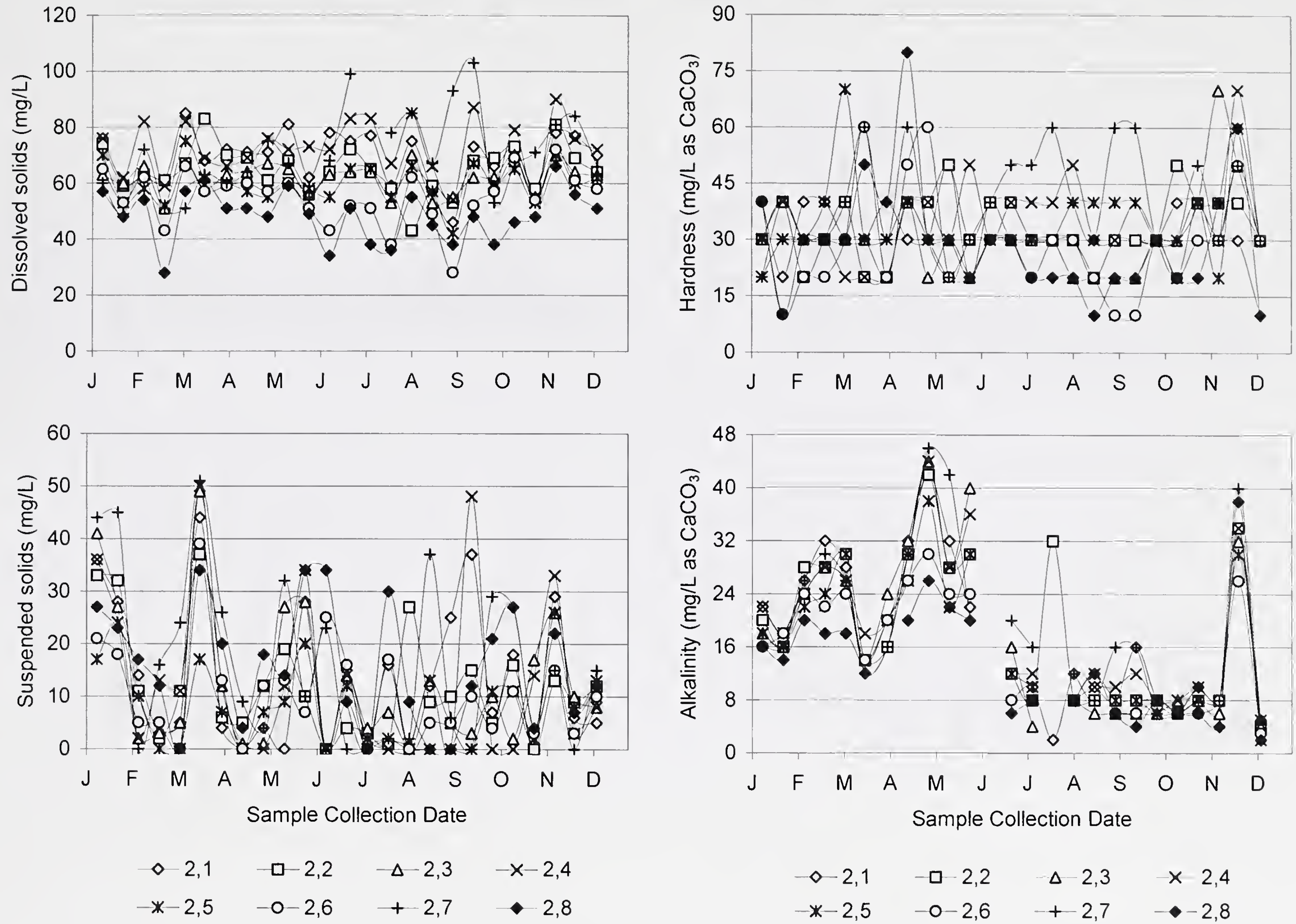


Fig. 2-4. 2002 filtered phosphorus, total phosphorus, ammonium-N, and nitrate-N measurements for Long Creek.

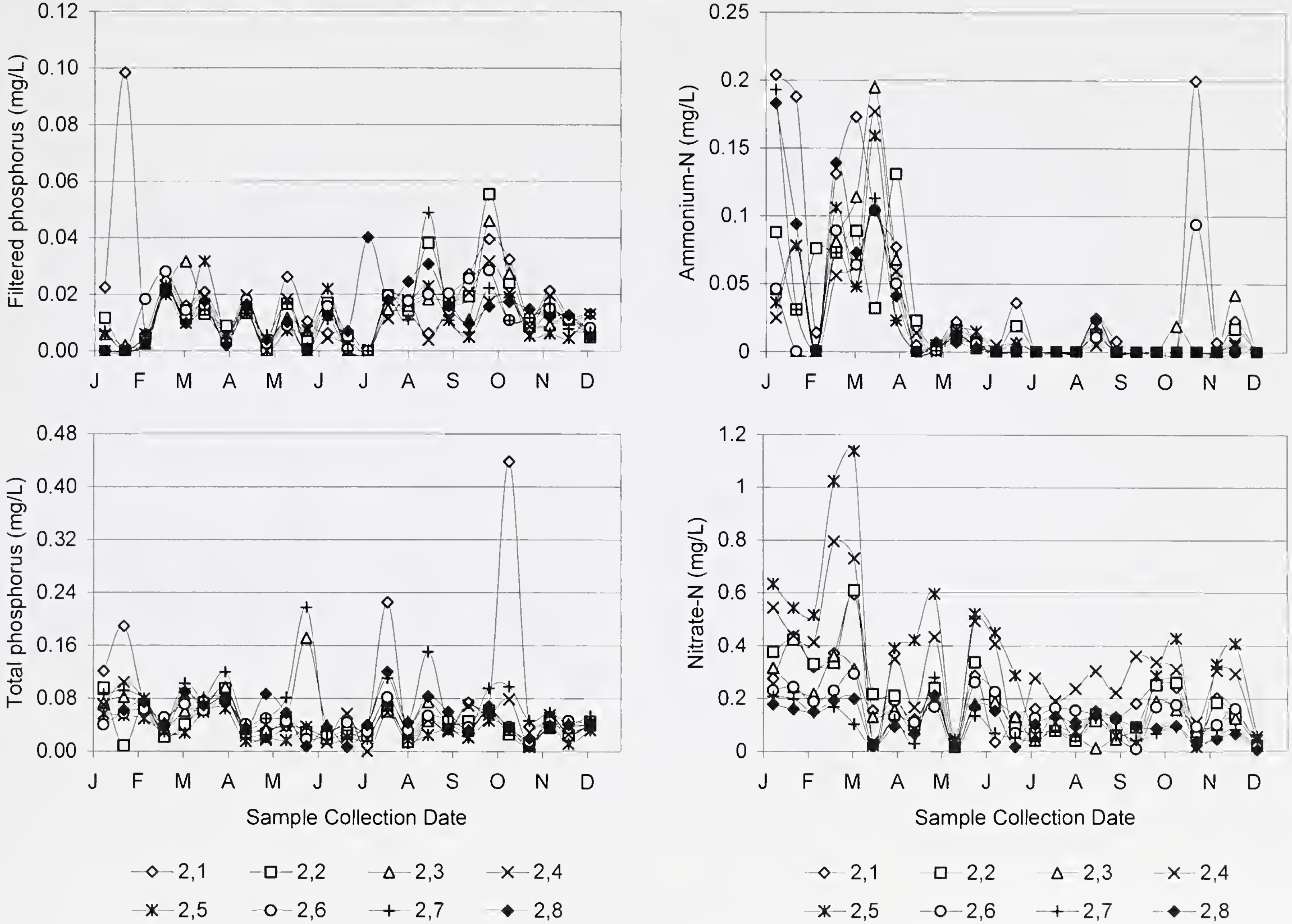


Fig. 2-5. 2002 nitrite-N, total nitrogen, fecal coliform, and enterococci measurements for Long Creek.

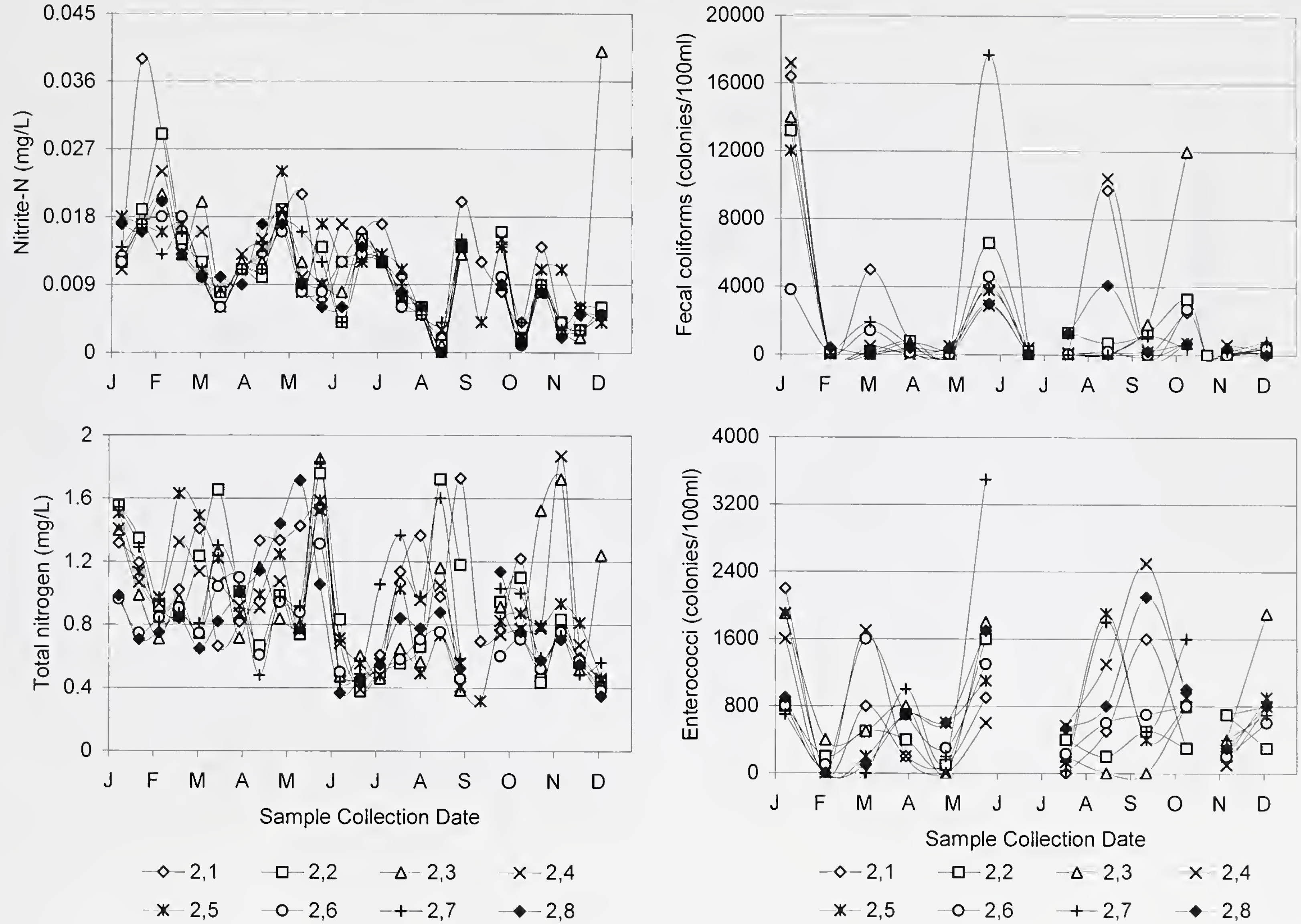


Fig. 2-6. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Long Creek sites 2,1, 2,2, 2,3, and 2,4.

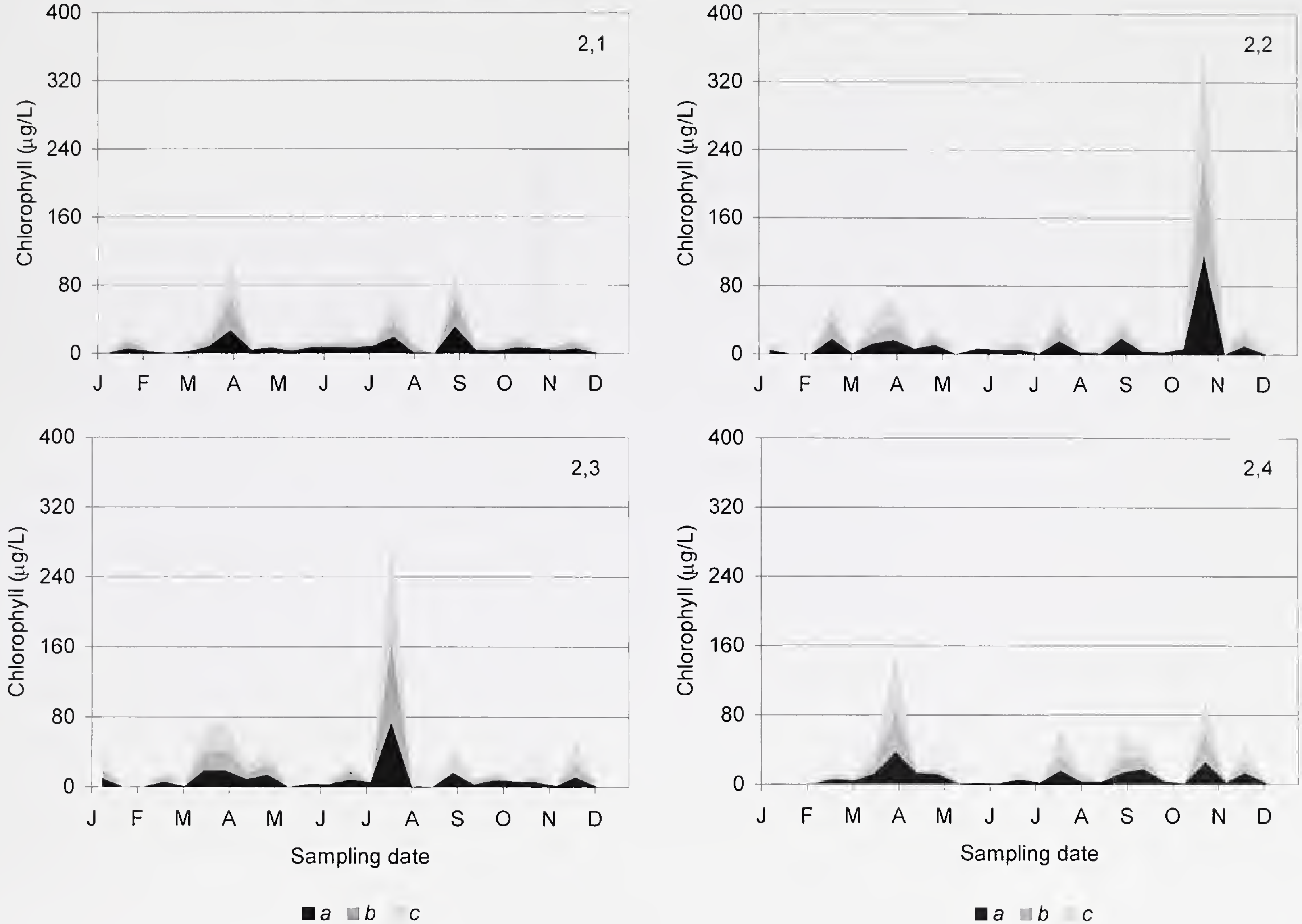


Fig. 2-7. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Long Creek sites 2,5, 2,6, 2,7, and 2,8.

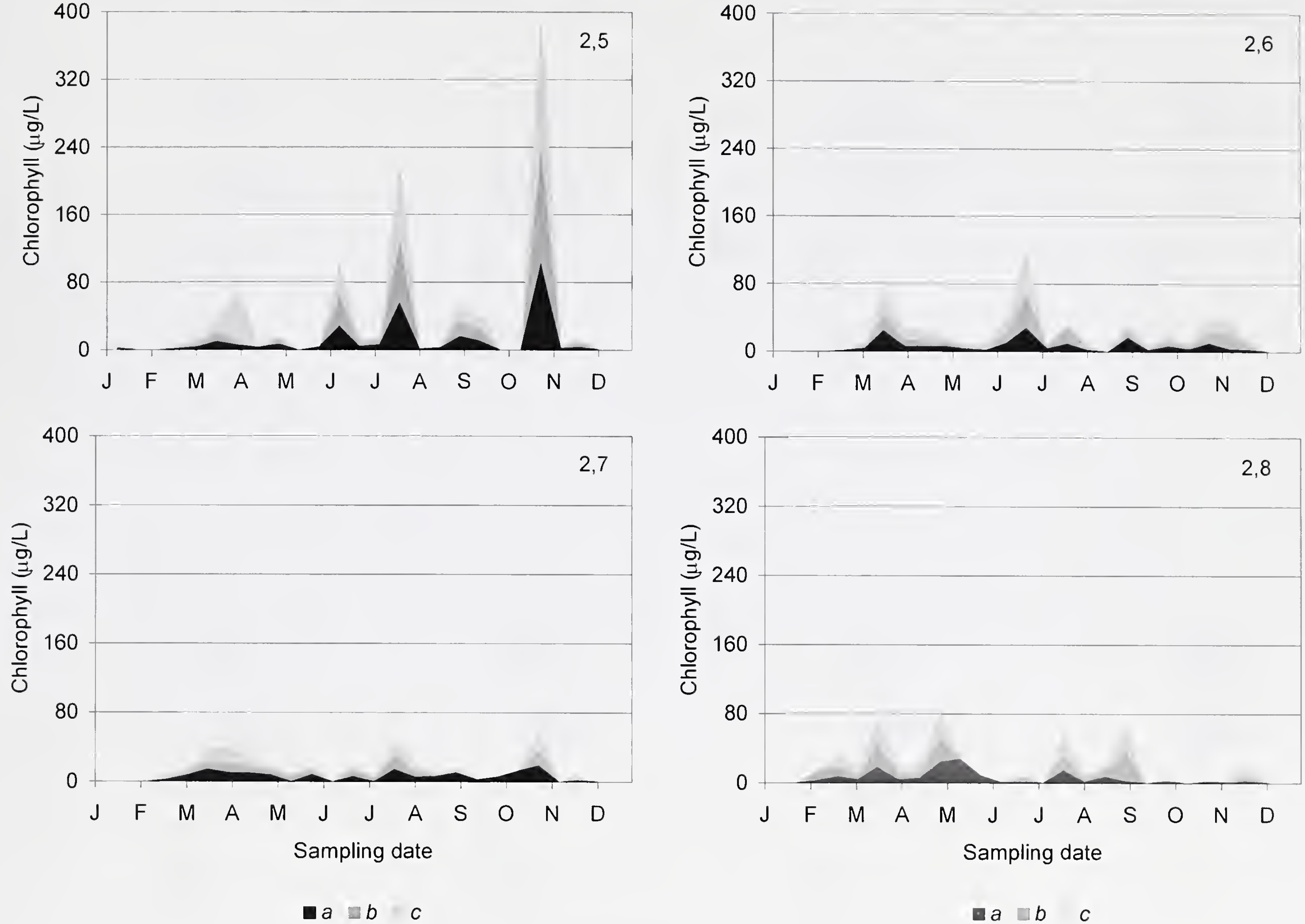


Fig. 2-8. 2002 seasonal pHmeasurements for Long Creek.

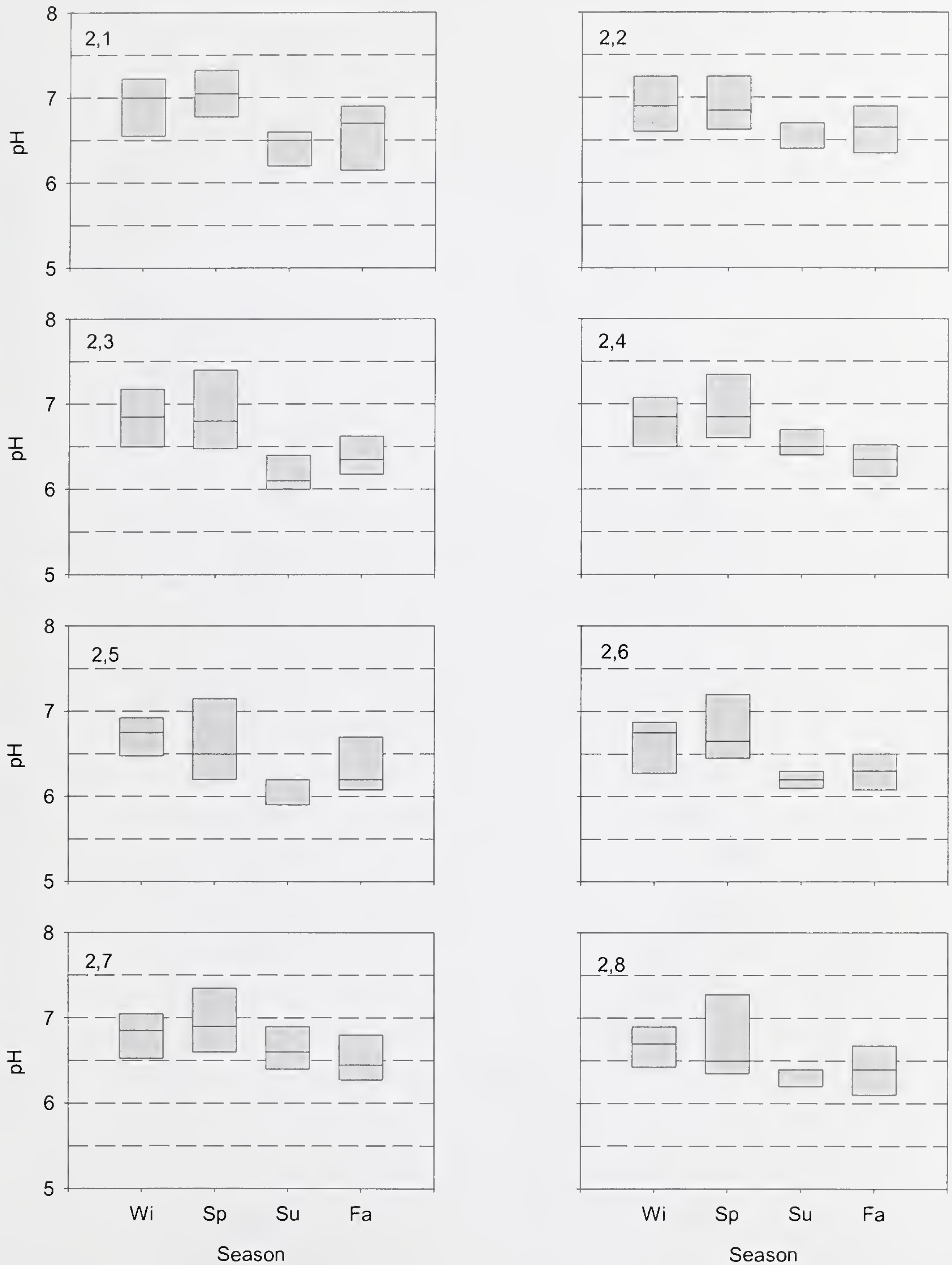


Fig. 4-1. 2002 water depth, temperature, dissolved oxygen, and conductivity measurements for Hotophia Creek.

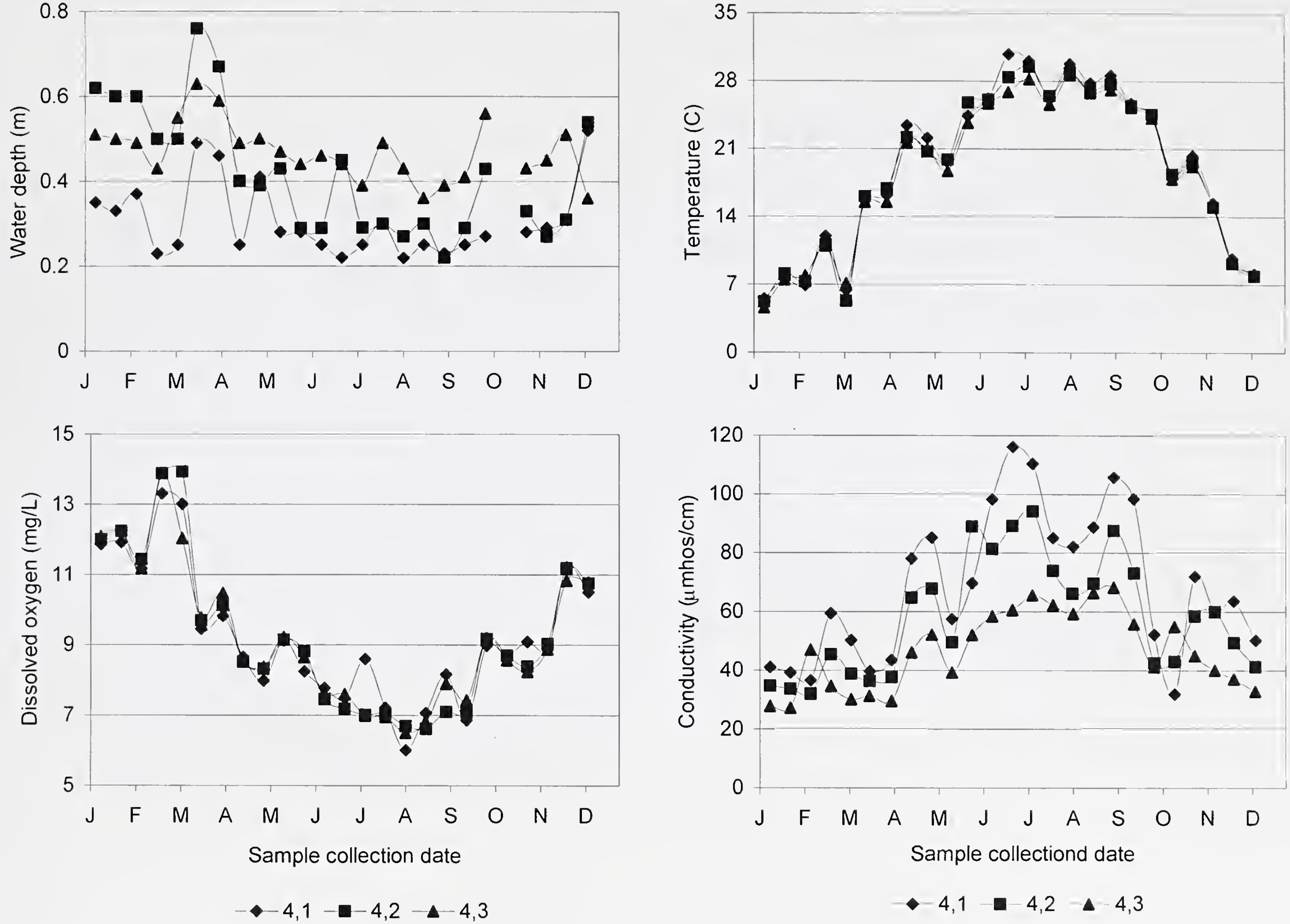


Fig. 4-2. 2002 pH, chlorophyll *a*, turbidity, and total solids measurements for Hotophia Creek.

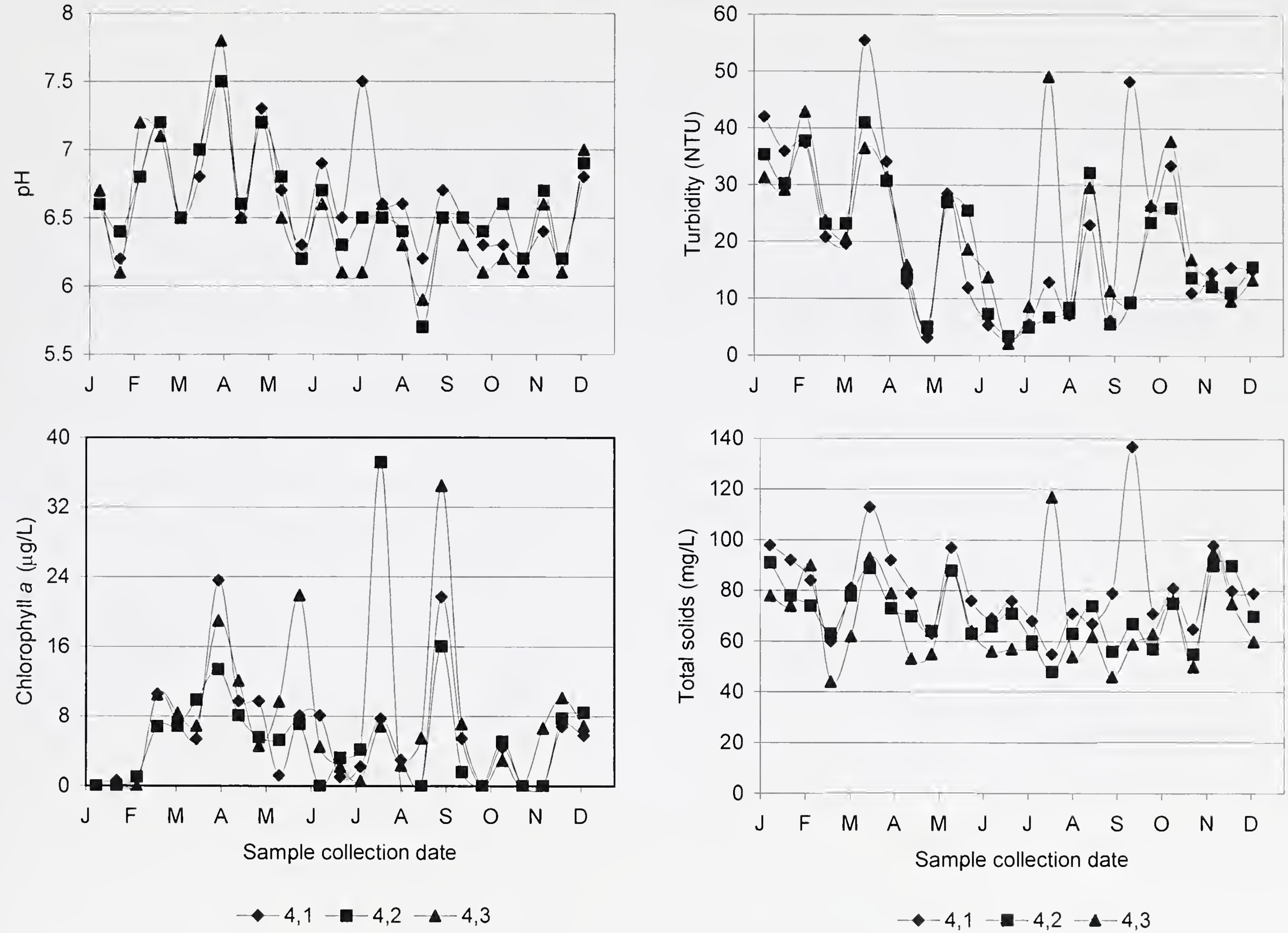


Fig. 4-3. 2002 dissolved and suspended solids, hardness, and alkalinity measurements for Hotophia Creek.

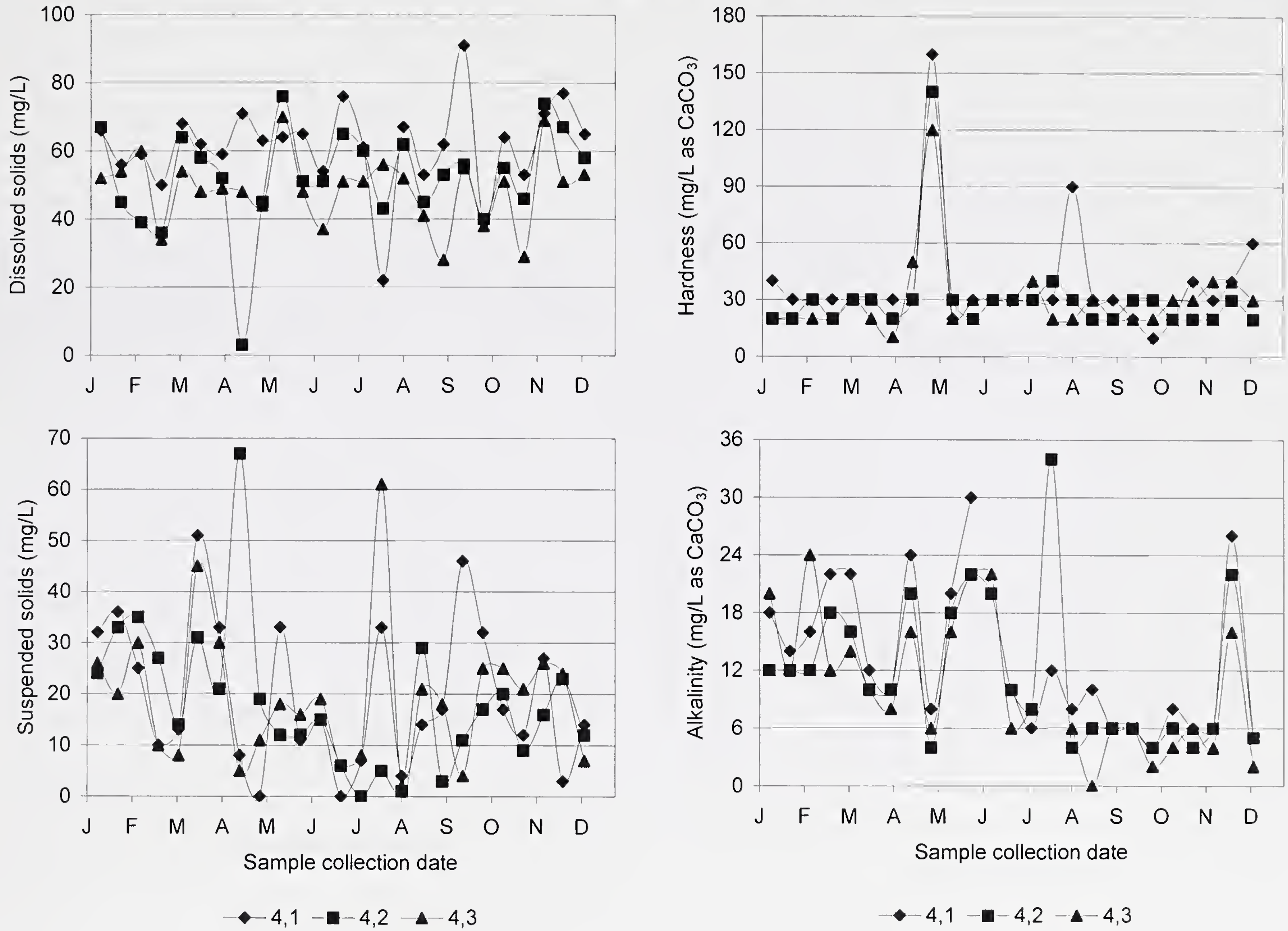


Fig. 4-4. 2002 filtered and total phosphorus, ammonium-N, and nitrate-N measurements for Hotophia Creek.

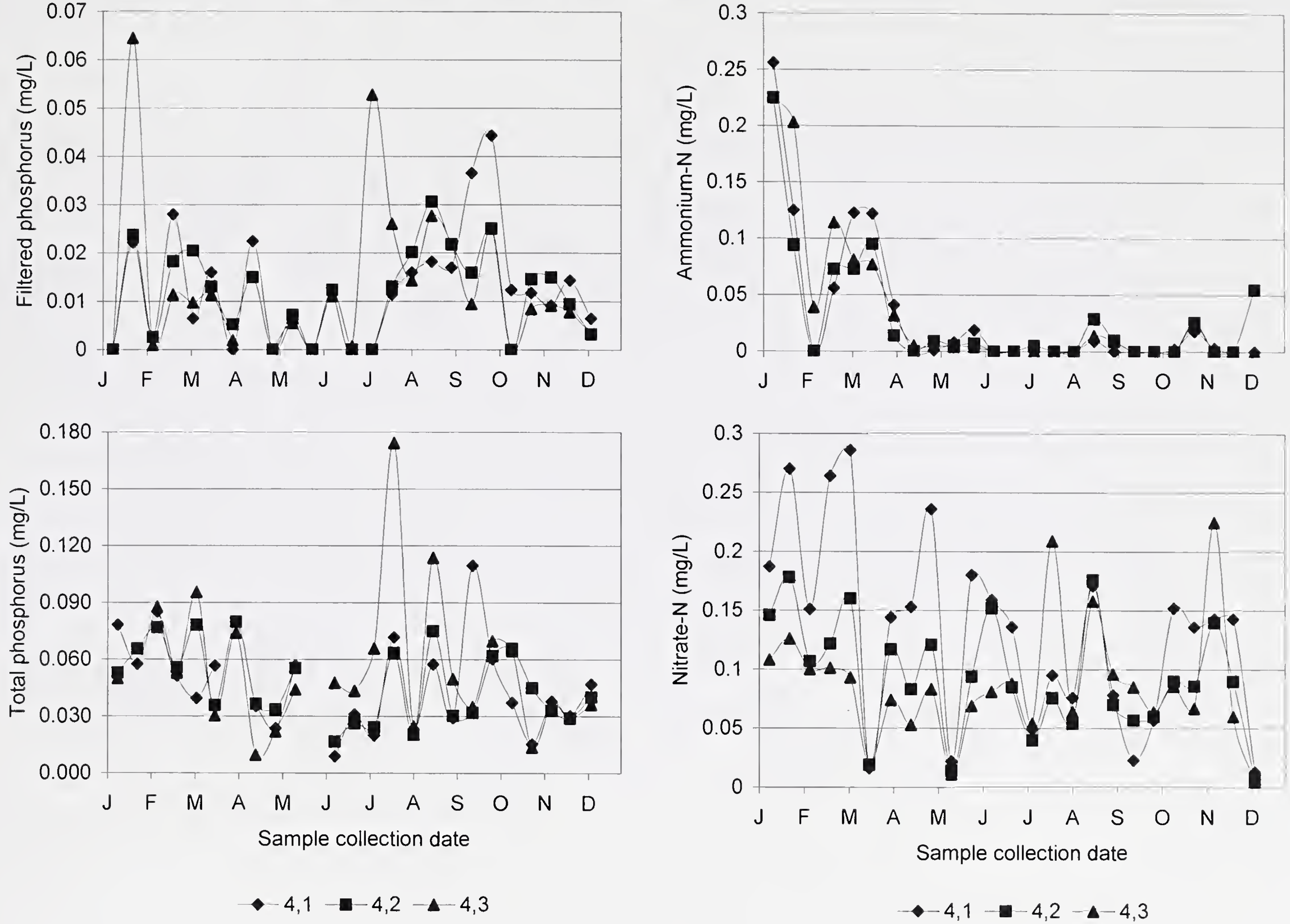


Fig. 4-5. 2002 nitrite-N, total nitrogen, fecal coliform, and enterococci measurements for Hotophia Creek.

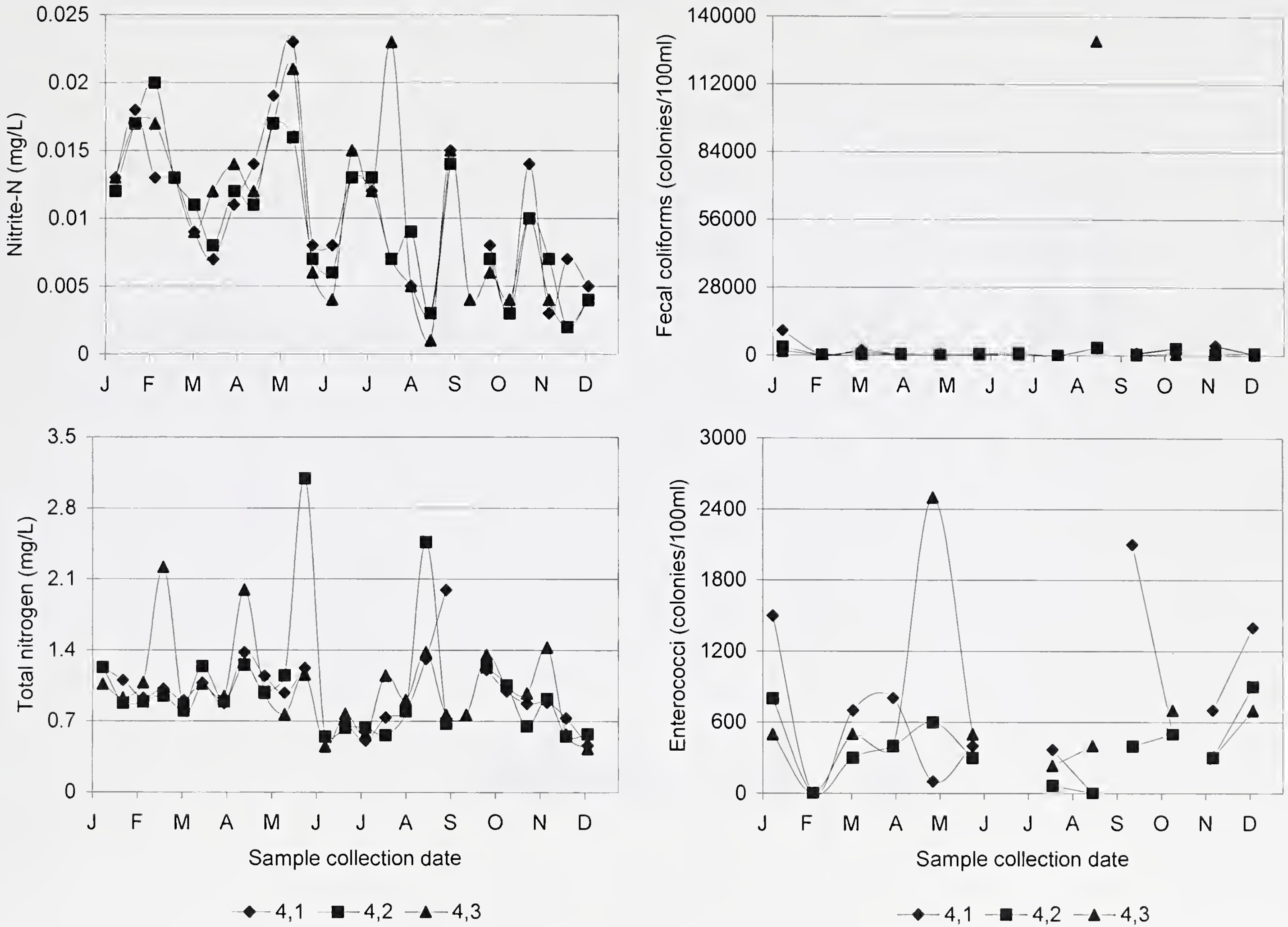


Fig. 4-6. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Hotophia Creek sites 4,1, 4,2, and 4,3.

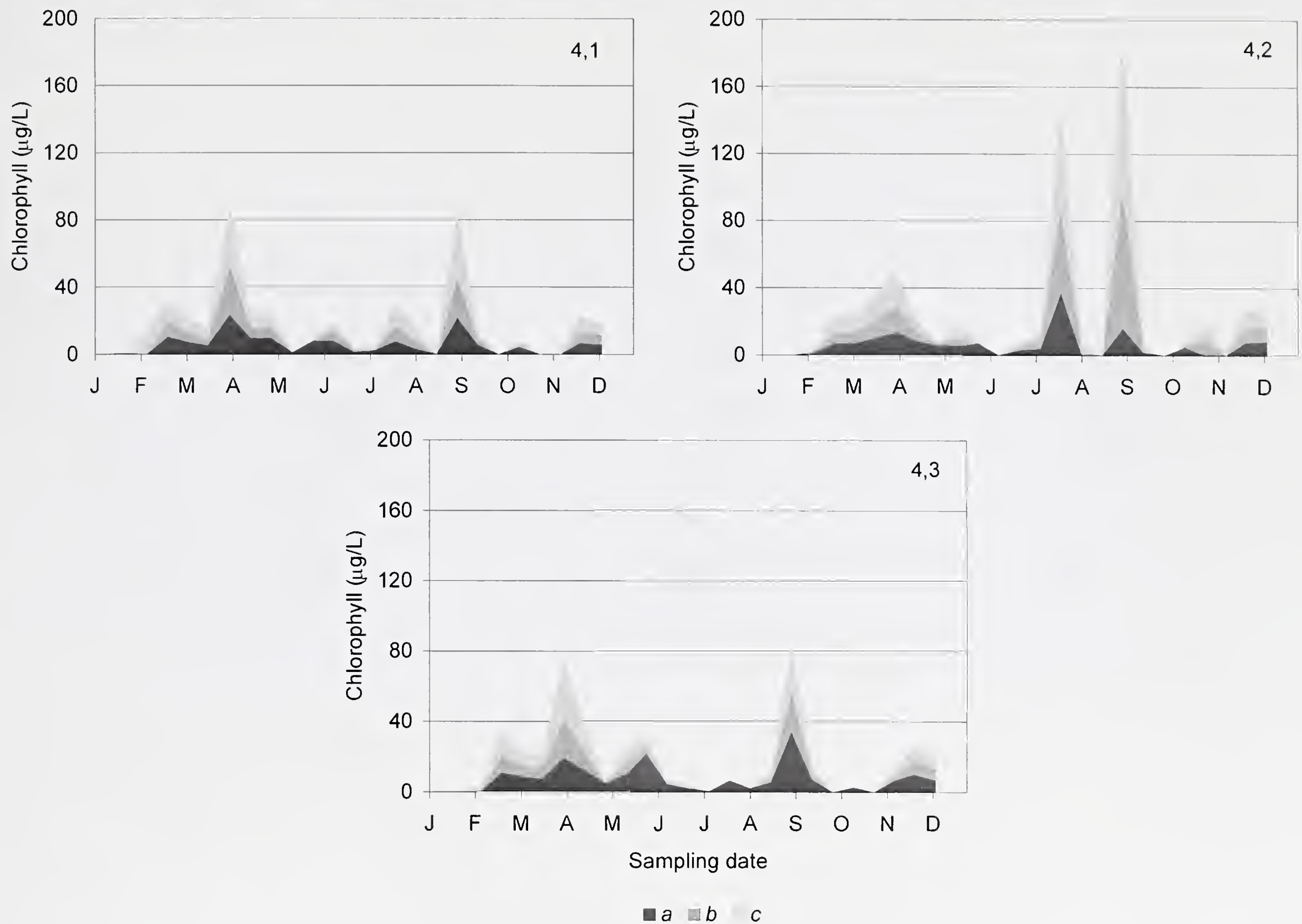


Fig. 4-7. 2002 seasonal pH measurements for Hotophia Creek.

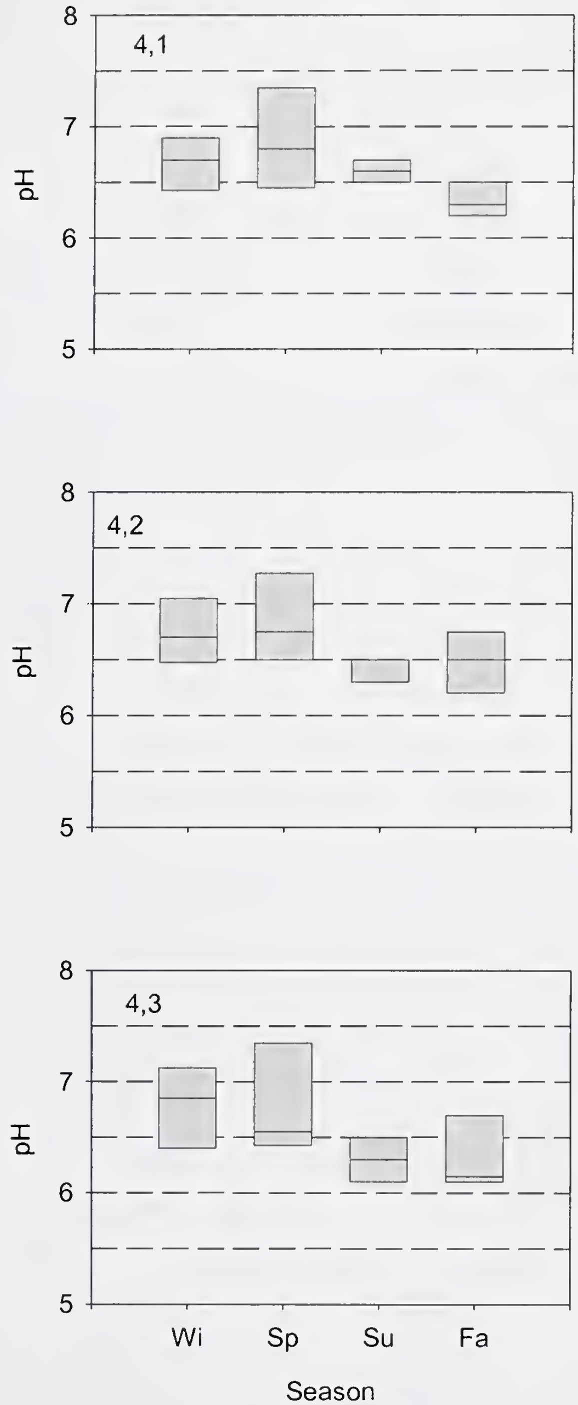


Fig. 8-1. 2002 water depth, temperature, dissolved oxygen, and conductivity measurements for Abiaca Creek.

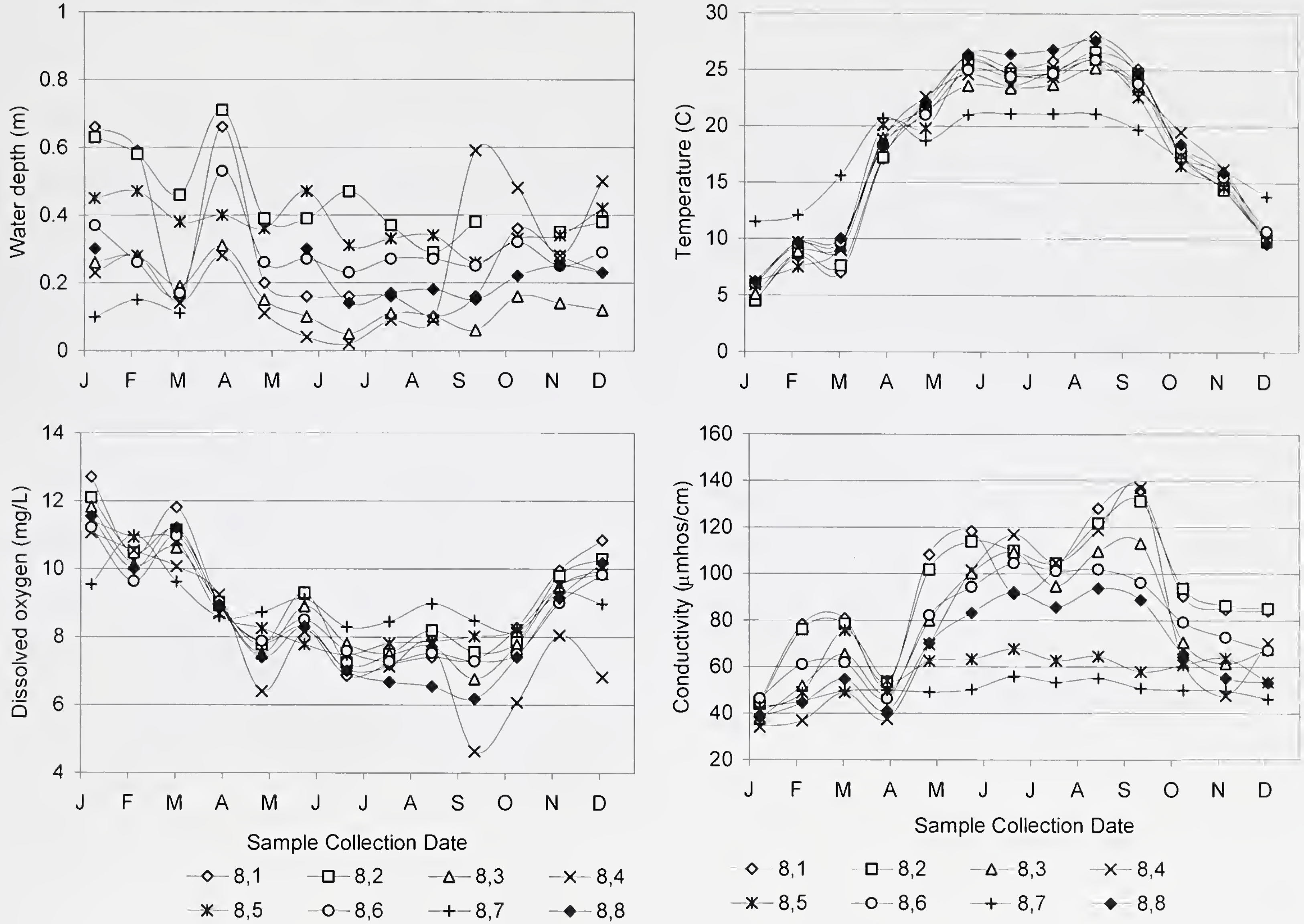


Fig. 8-2. 2002 pH, chlorophyll *a*, turbidity, and total solids measurements for Abiaca Creek.

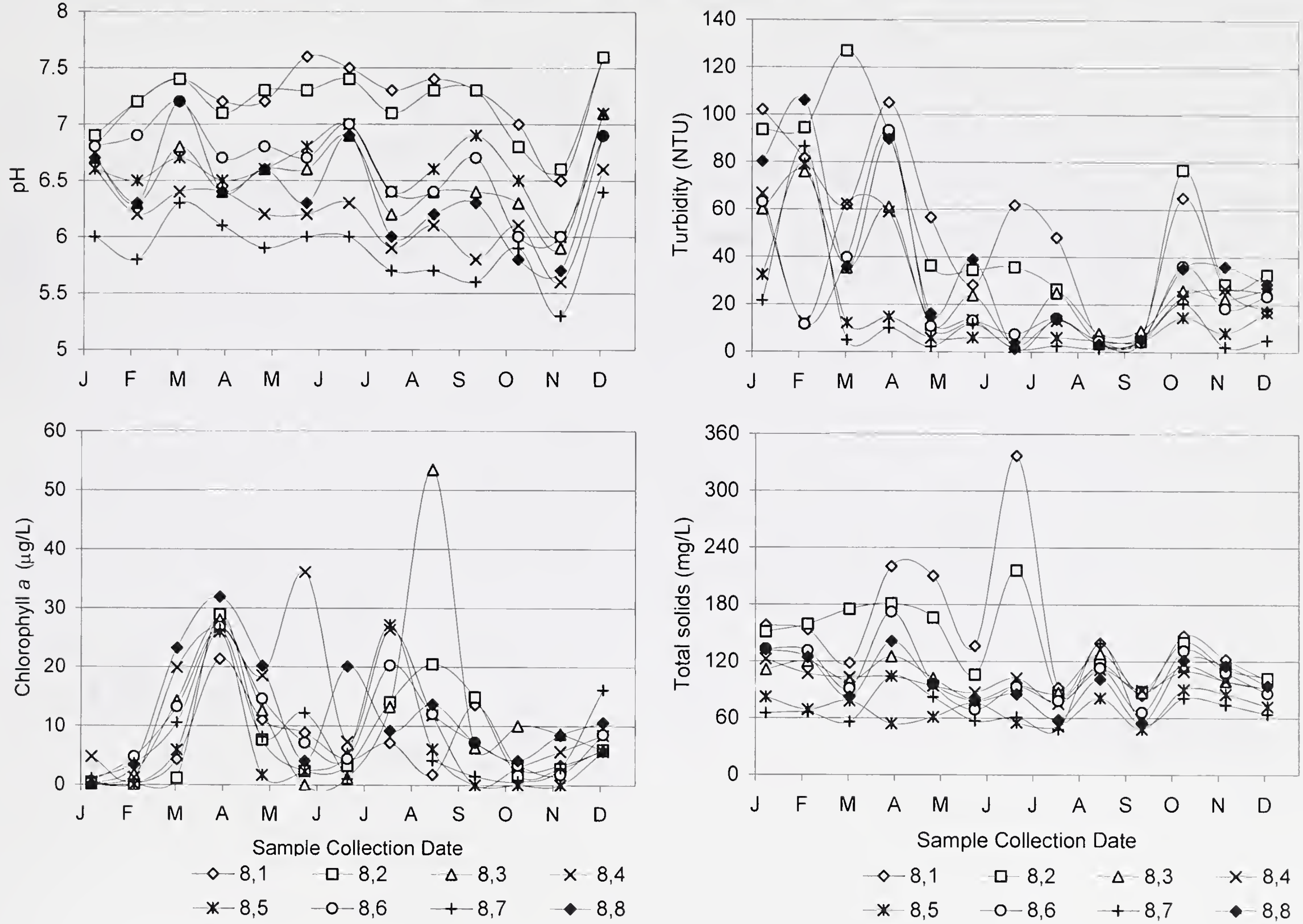


Fig. 8-3. 2002 dissolved and suspended solids, hardness, and alkalinity measurements for Abiaca Creek.

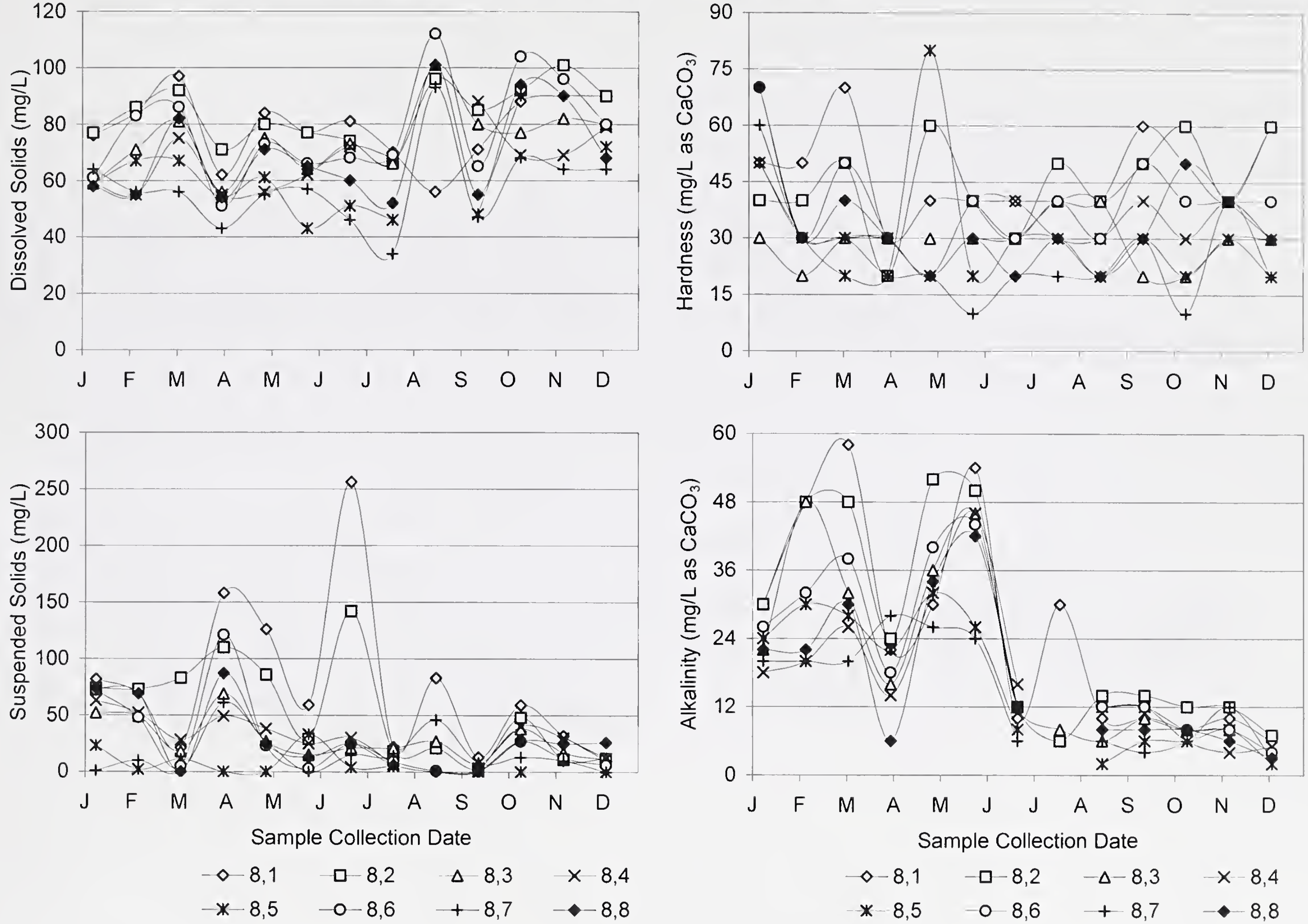


Fig. 8-4. 2002 filtered and total phosphorus, ammonium-N, and nitrate-N measurements for Abiaca Creek.

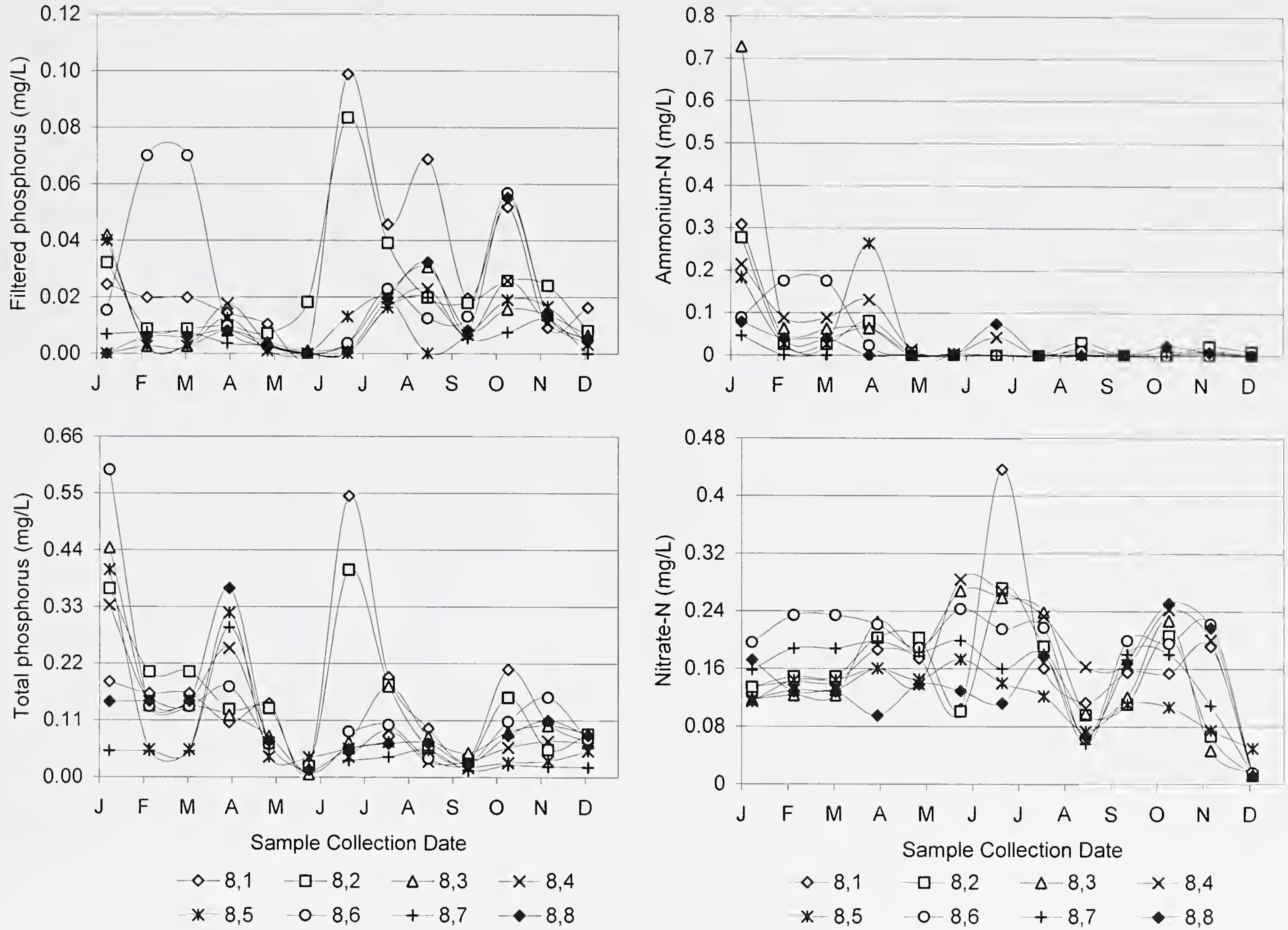


Fig. 8-5. 2002 nitrite-N, total nitrogen, fecal coliform, and enterococci measurements for Abiaca Creek.

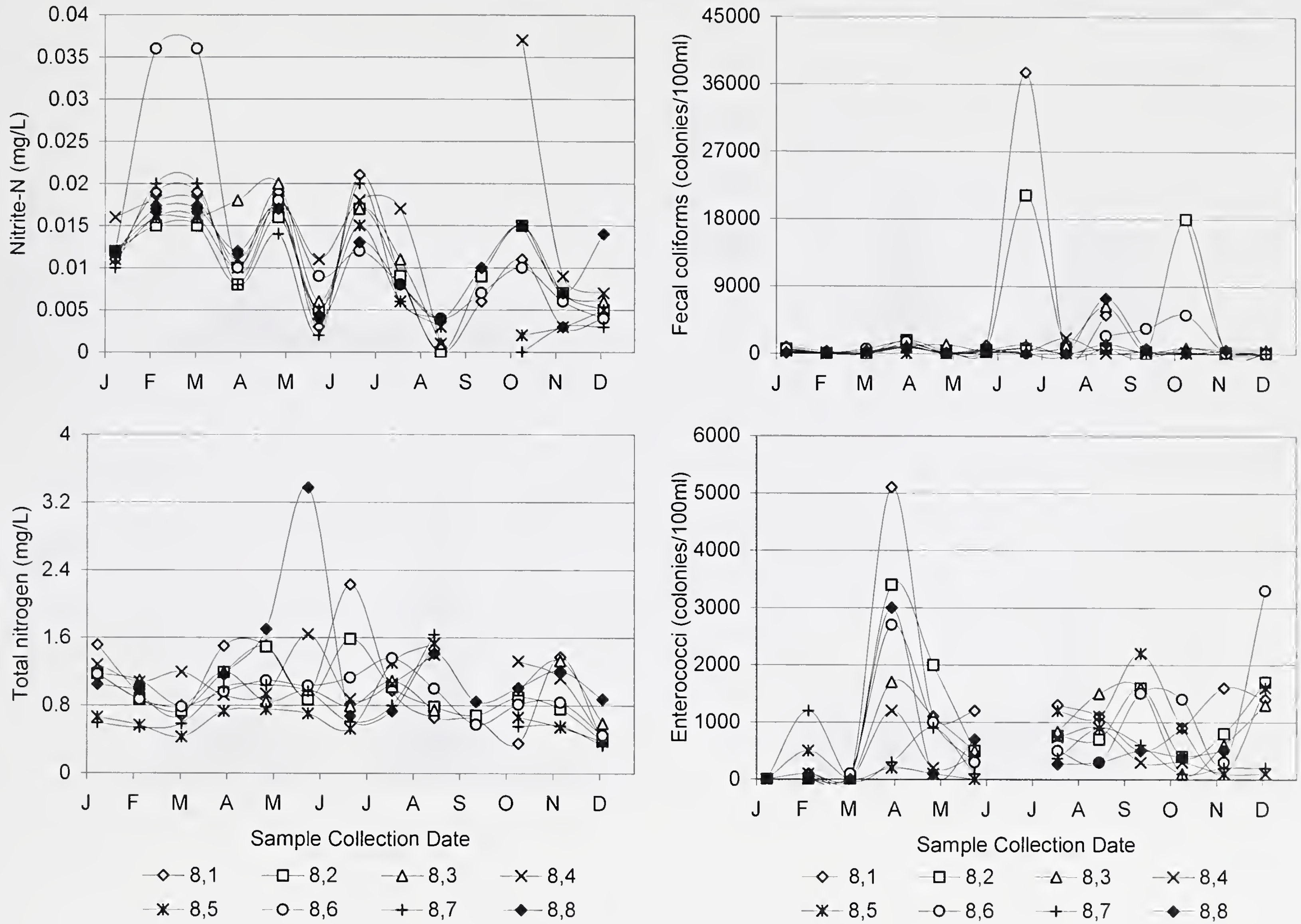


Fig. 8-6. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Abiaca Creek sites 8,1, 8,2, 8,3, and 8,4.

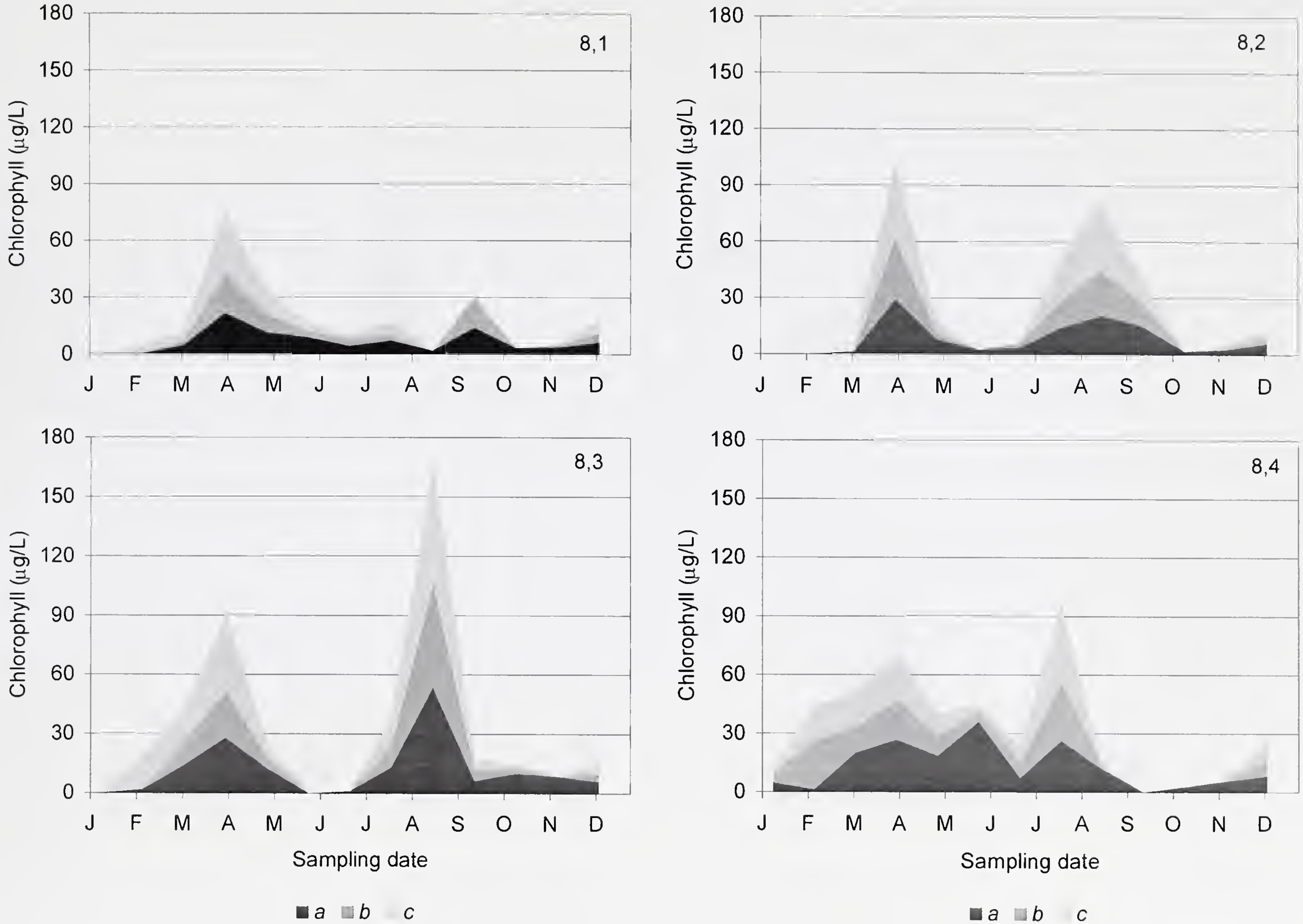


Fig. 8-7. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Abiaca Creek sites 8,5, 8,6, 8,7, and 8,8.

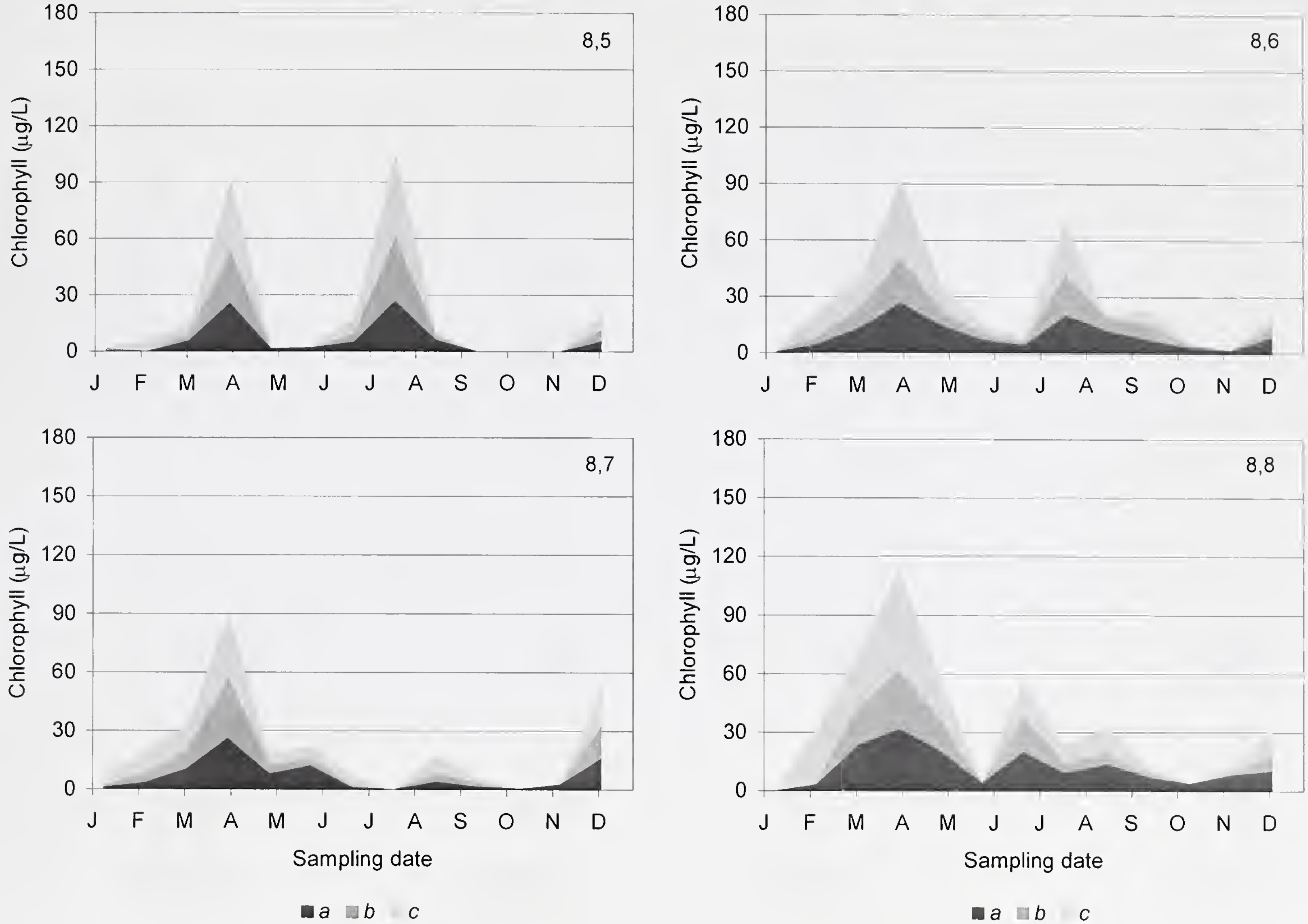


Fig. 8-8. 2002 seasonal pH measurements for Abiaca Creek.

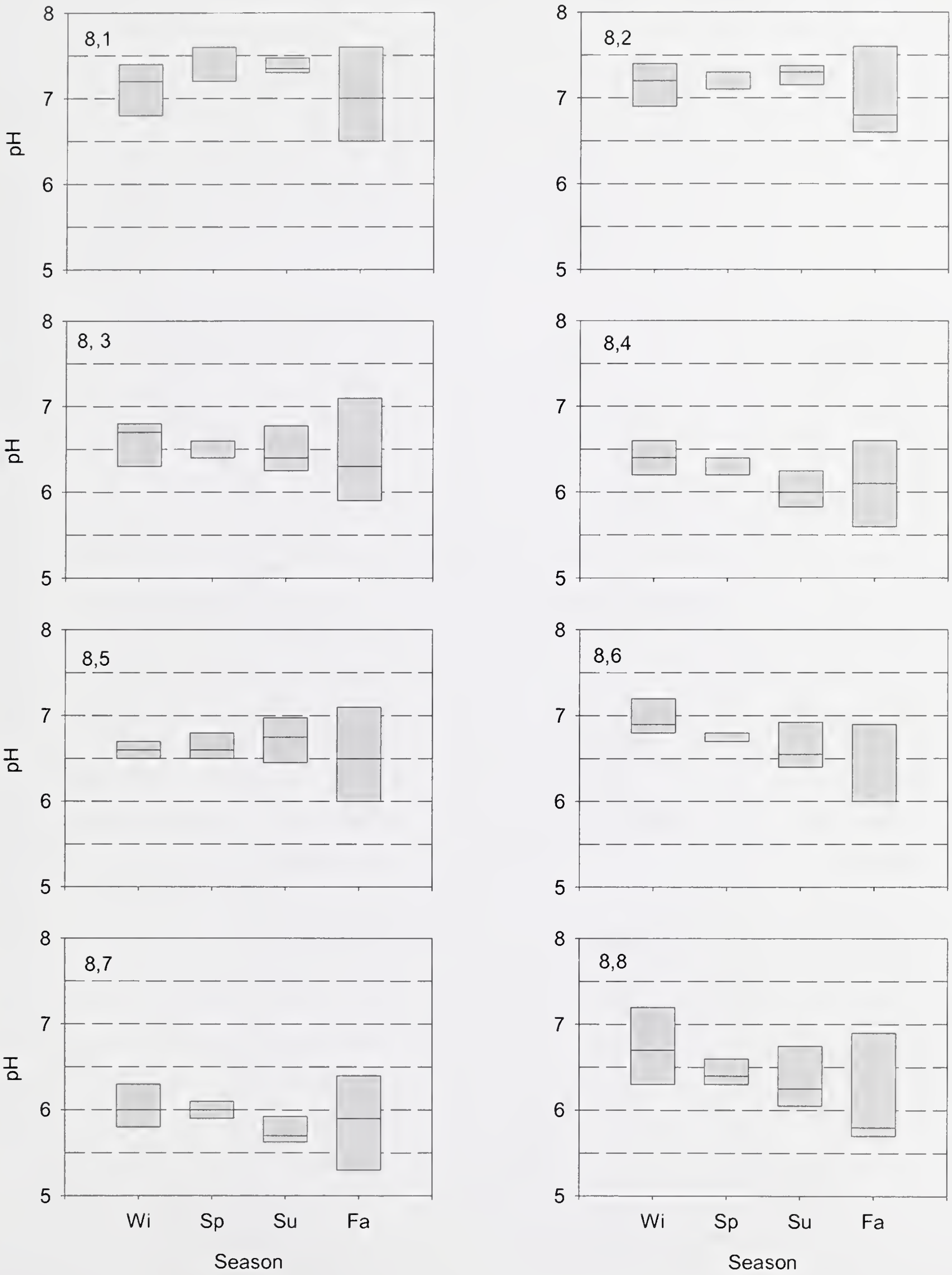


Fig. 9-1. 2002 water depth, temperature, dissolved oxygen, and conductivity measurements for Toby Tubby Creek.

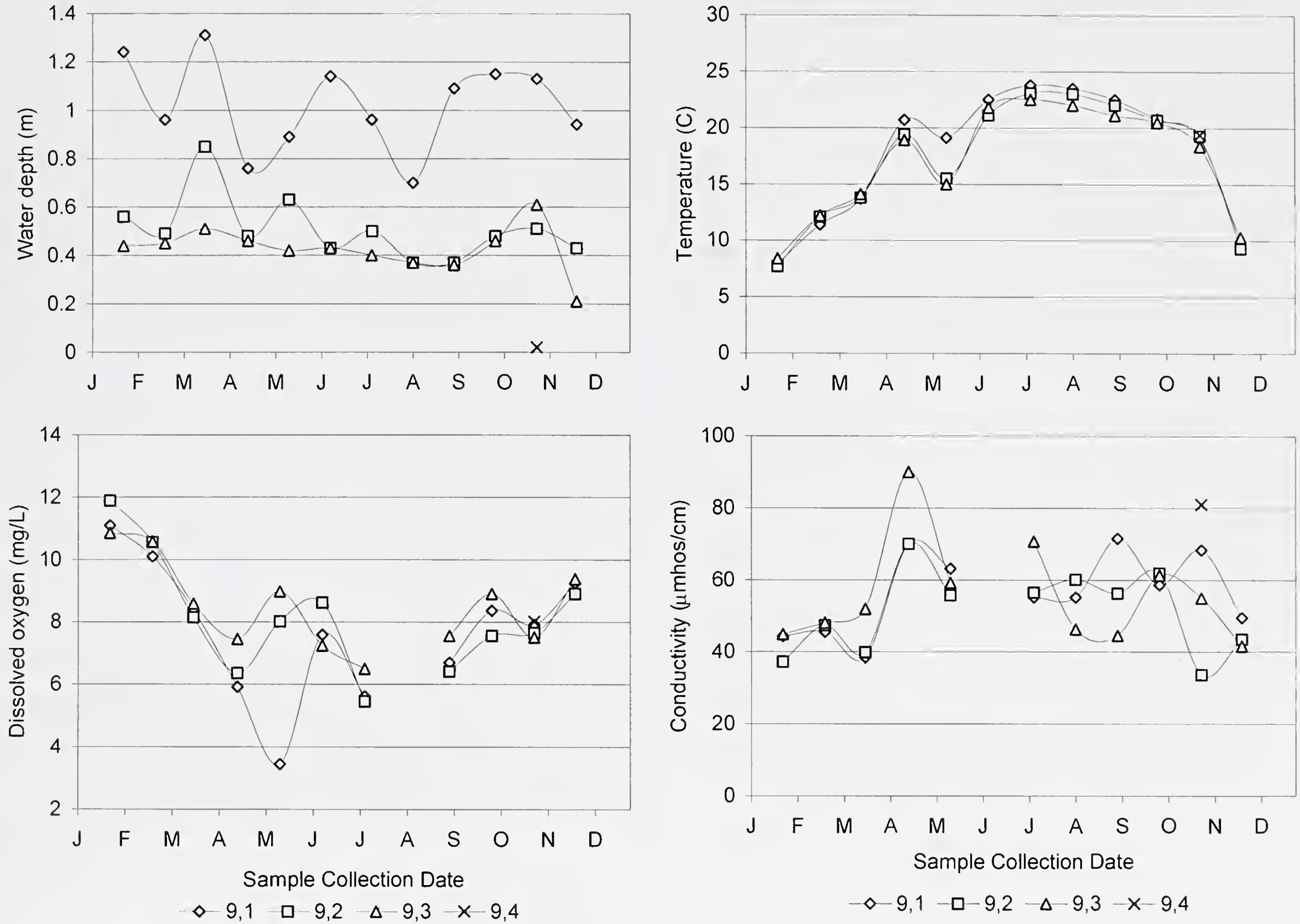


Fig. 9-2. 2002 pH, chlorophyll *a*, turbidity, and total solids measurements for Toby Tubby Creek.

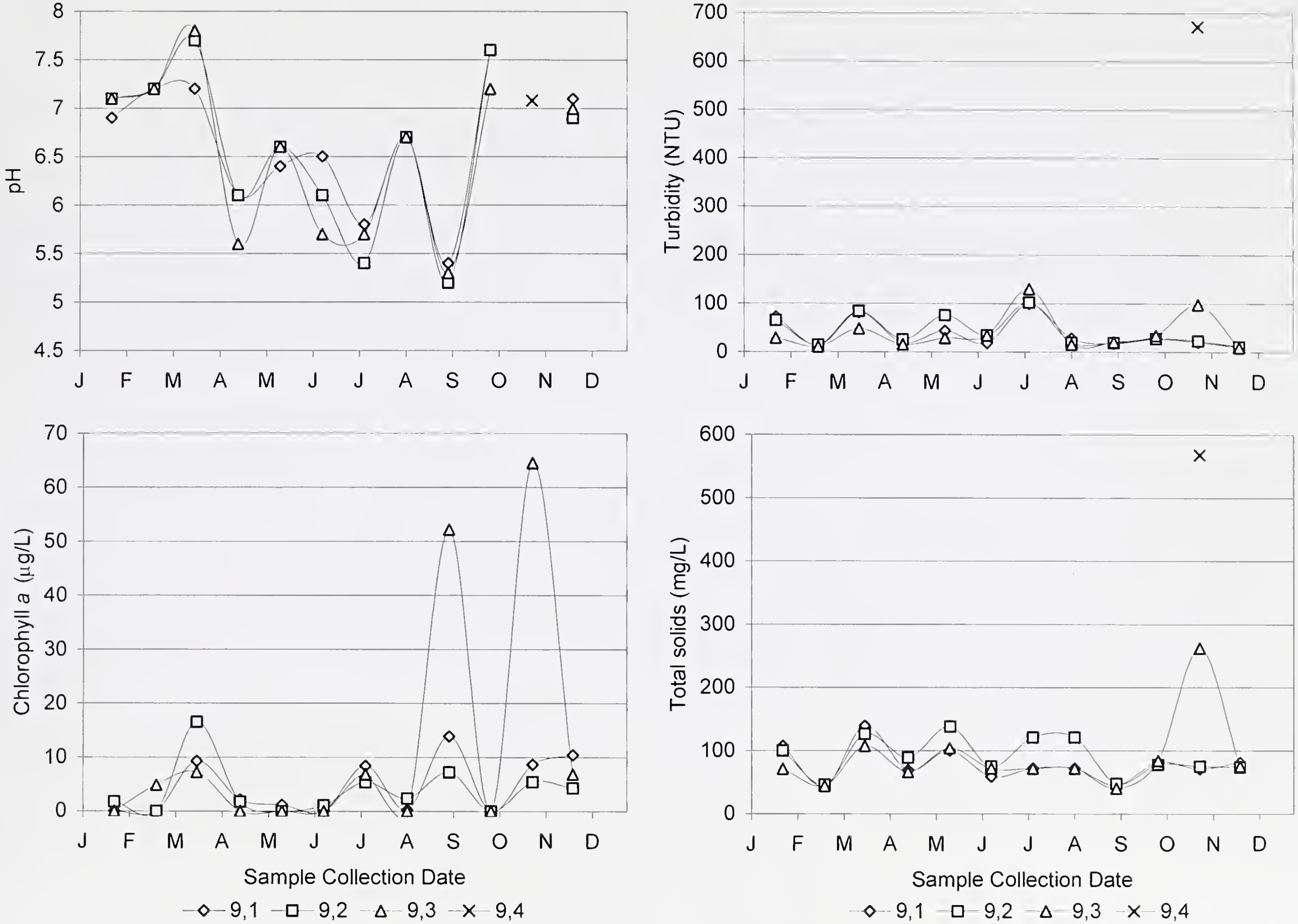


Fig. 9-3. 2002 dissolved and suspended solids, hardness, and alkalinity measurements for Toby Tubby Creek.

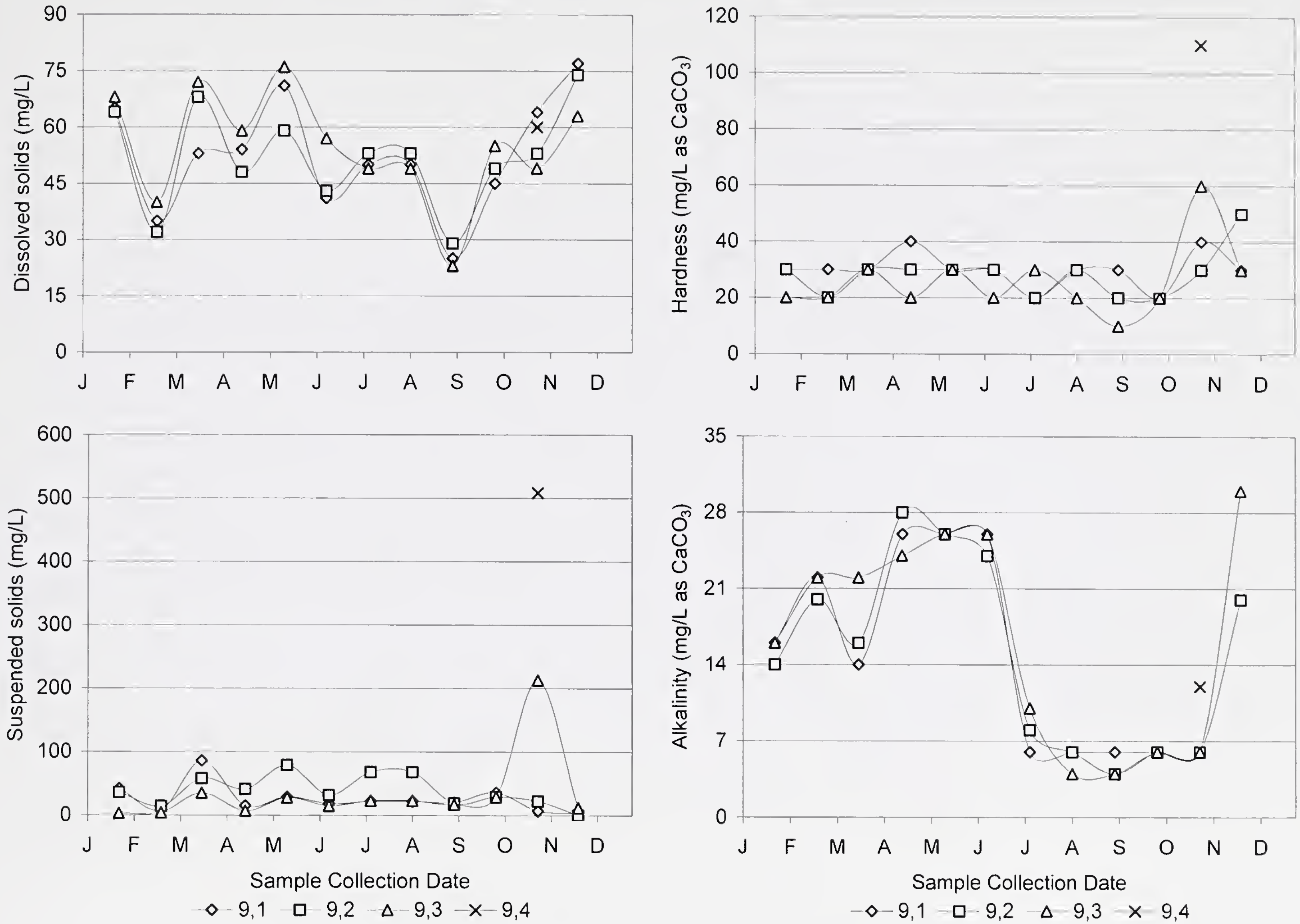


Fig. 9-4. 2002 filtered and total phosphorus, ammonium-N, and nitrate-N measurements for Toby Tubby Creek.

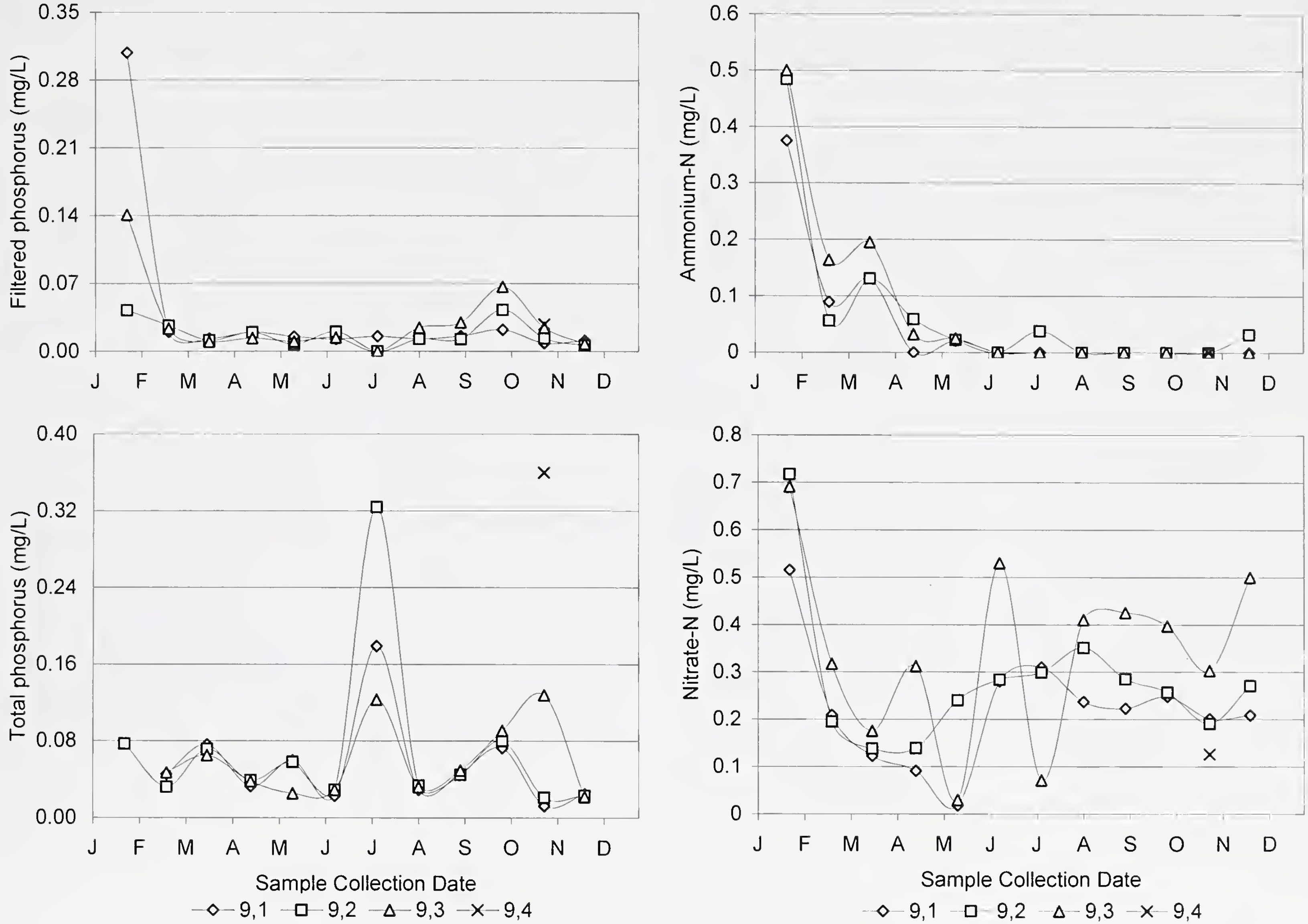


Fig. 9-5. 2002 nitrite-N, total nitrogen, fecal coliform, and enterococci measurements for Toby Tubby Creek.

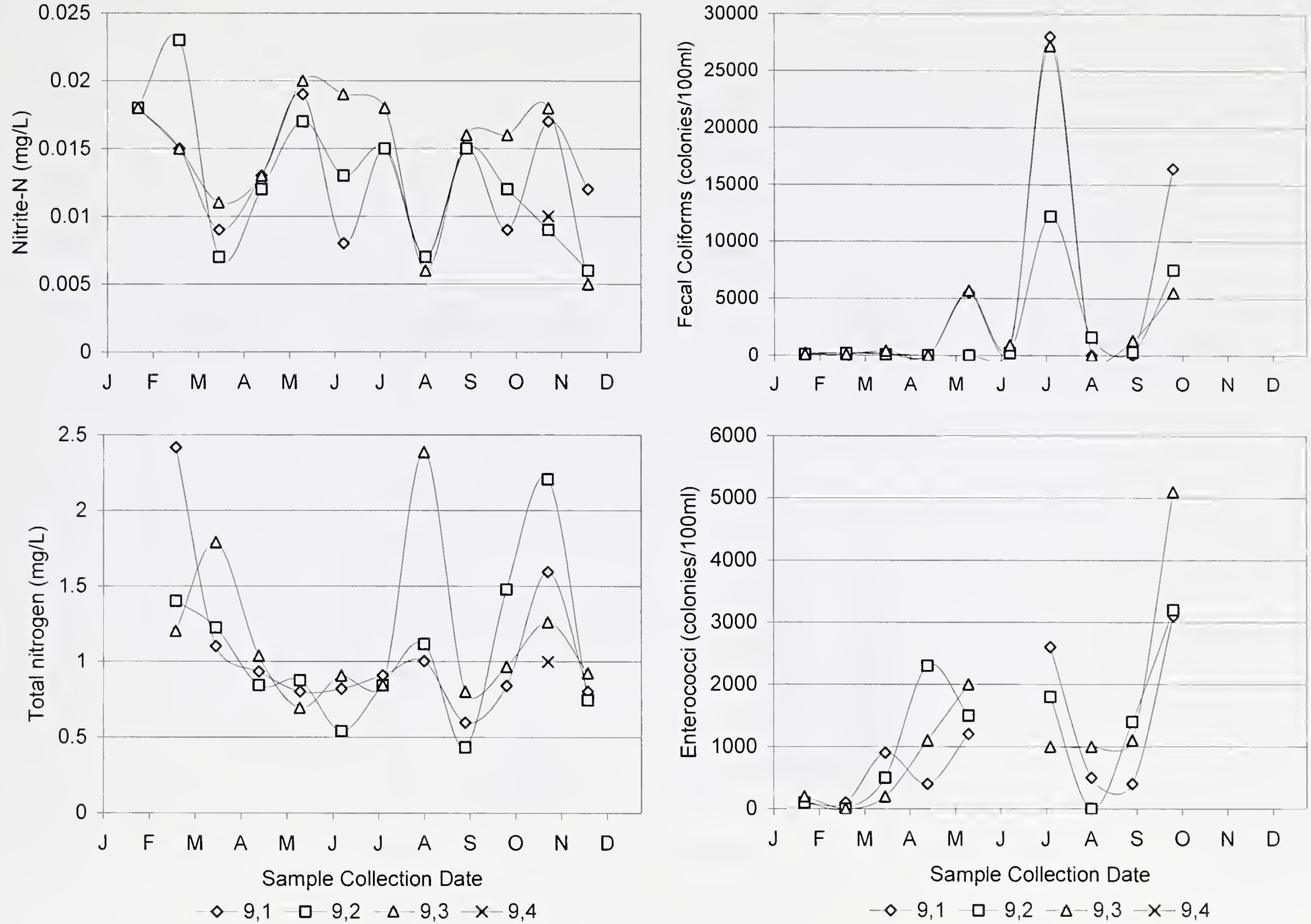


Fig. 9-6. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Toby Tubby Creek sites 9,1, 9,2, and 9,3.

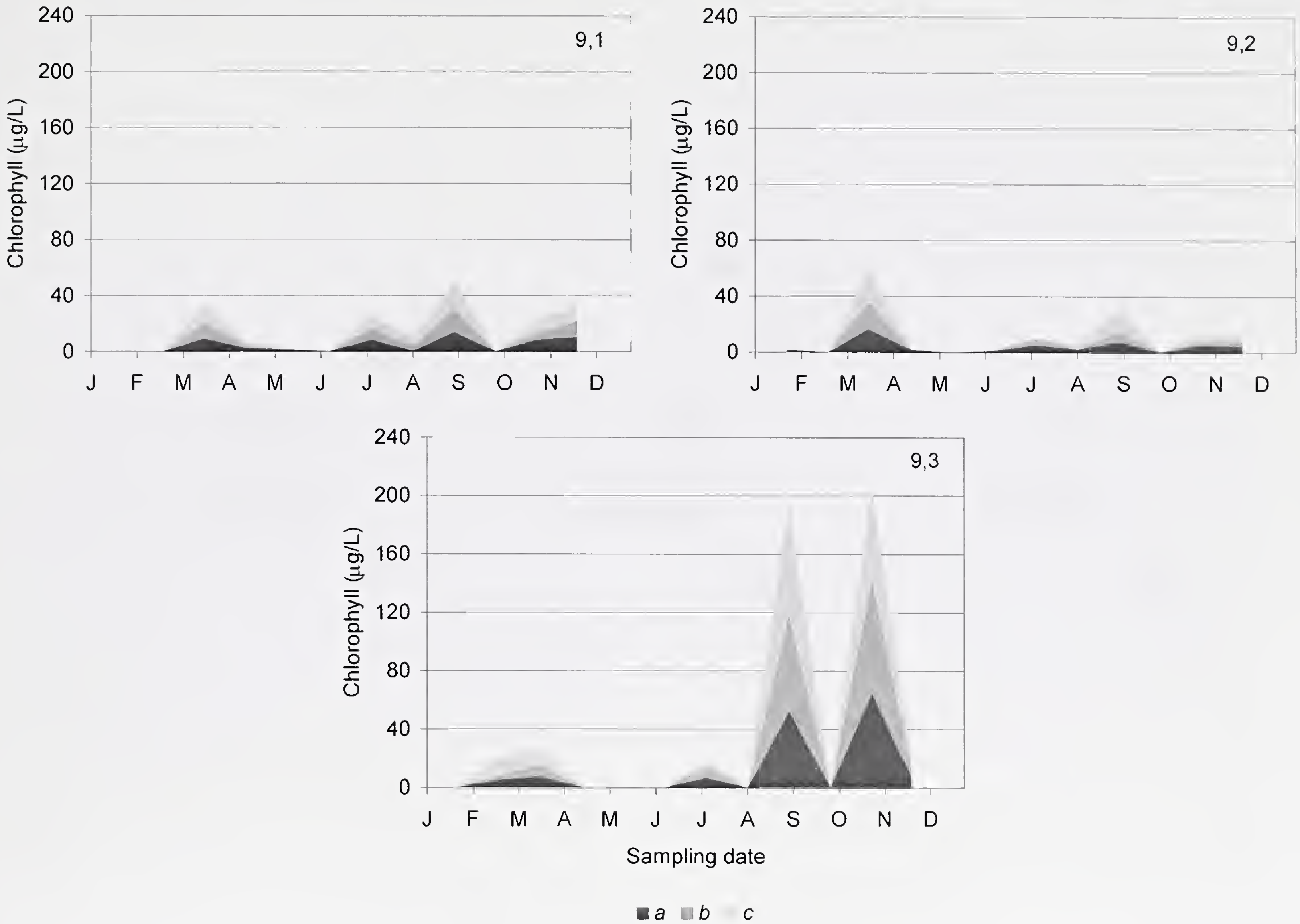


Fig. 9-7. 2002 seasonal pH measurements for Toby Tubby Creek.

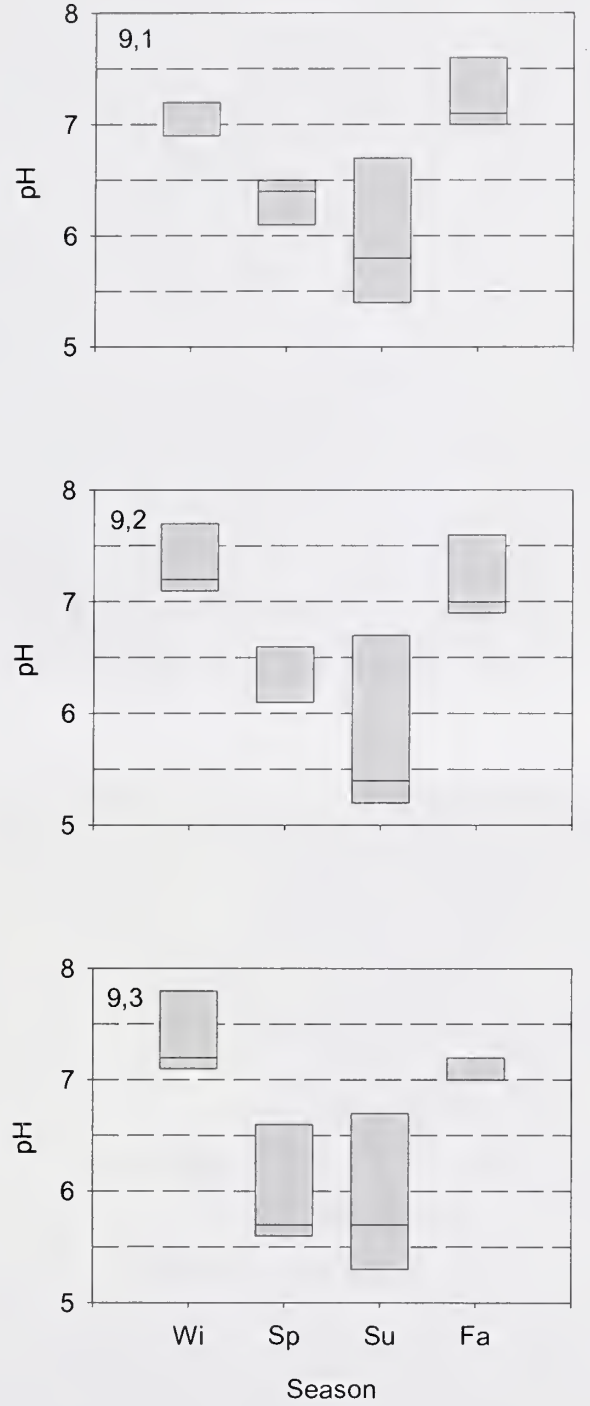


Figure C. Toby Tubby Creek site 9,3 (A) upstream and (B) downstream.

A

B

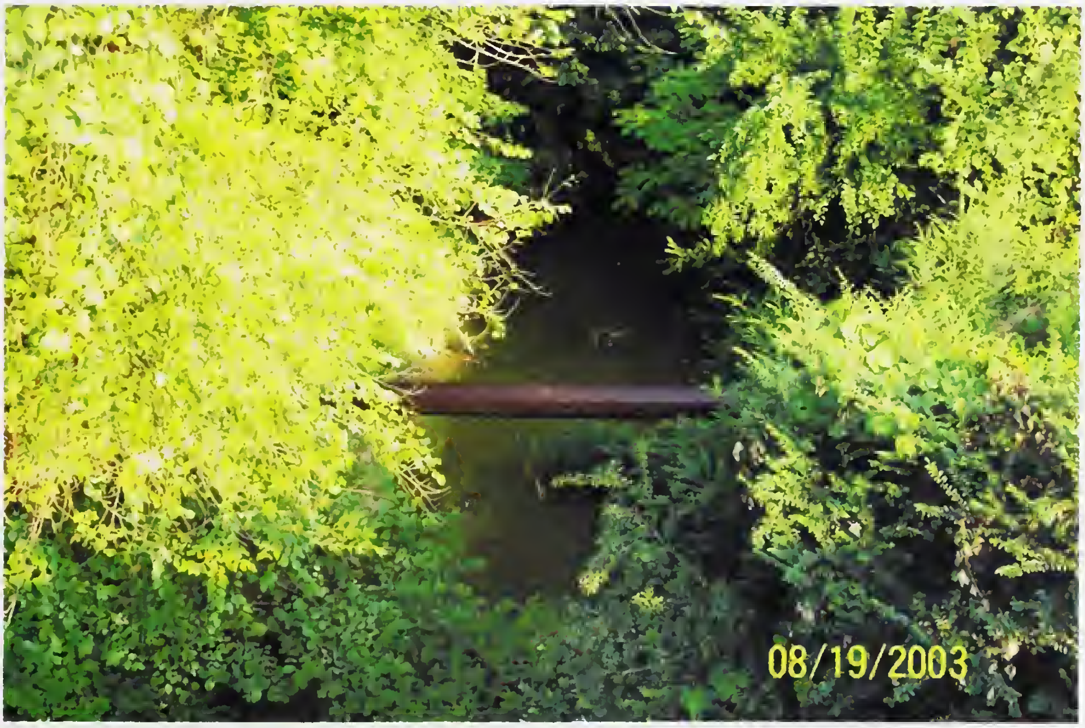


Fig. 13-1. 2002 water depth, temperature, dissoved oxygen, and conductivity measurements for Burney Branch Creek.

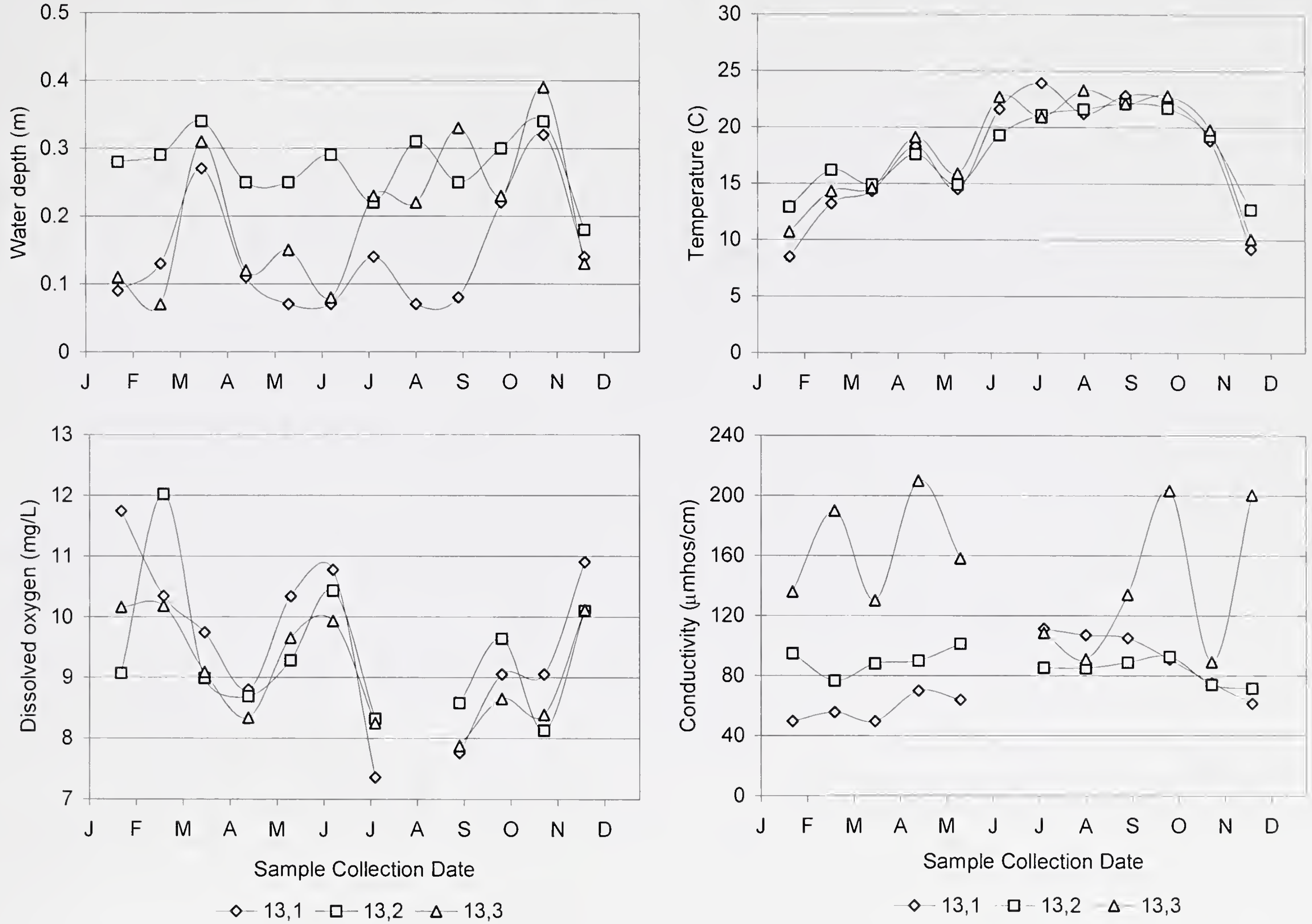


Fig. 13-2. 20002 pH, chlorophyll *a*, turbidity, and total solids measurements for Burney Branch Creek.

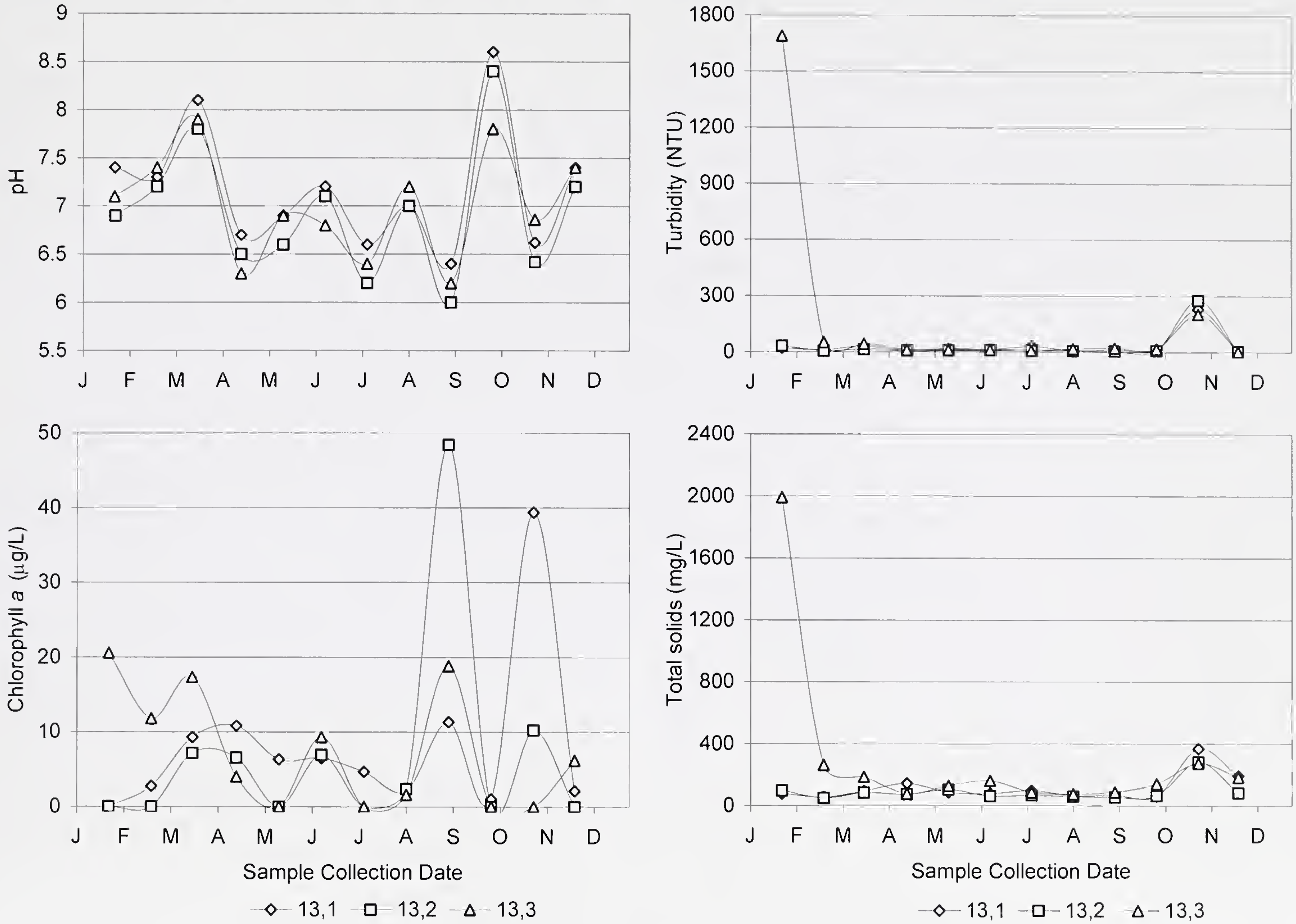


Fig. 13-3. 2002 dissolved and suspended solids, hardness, and alkalinity measurements for Burney Branch Creek.

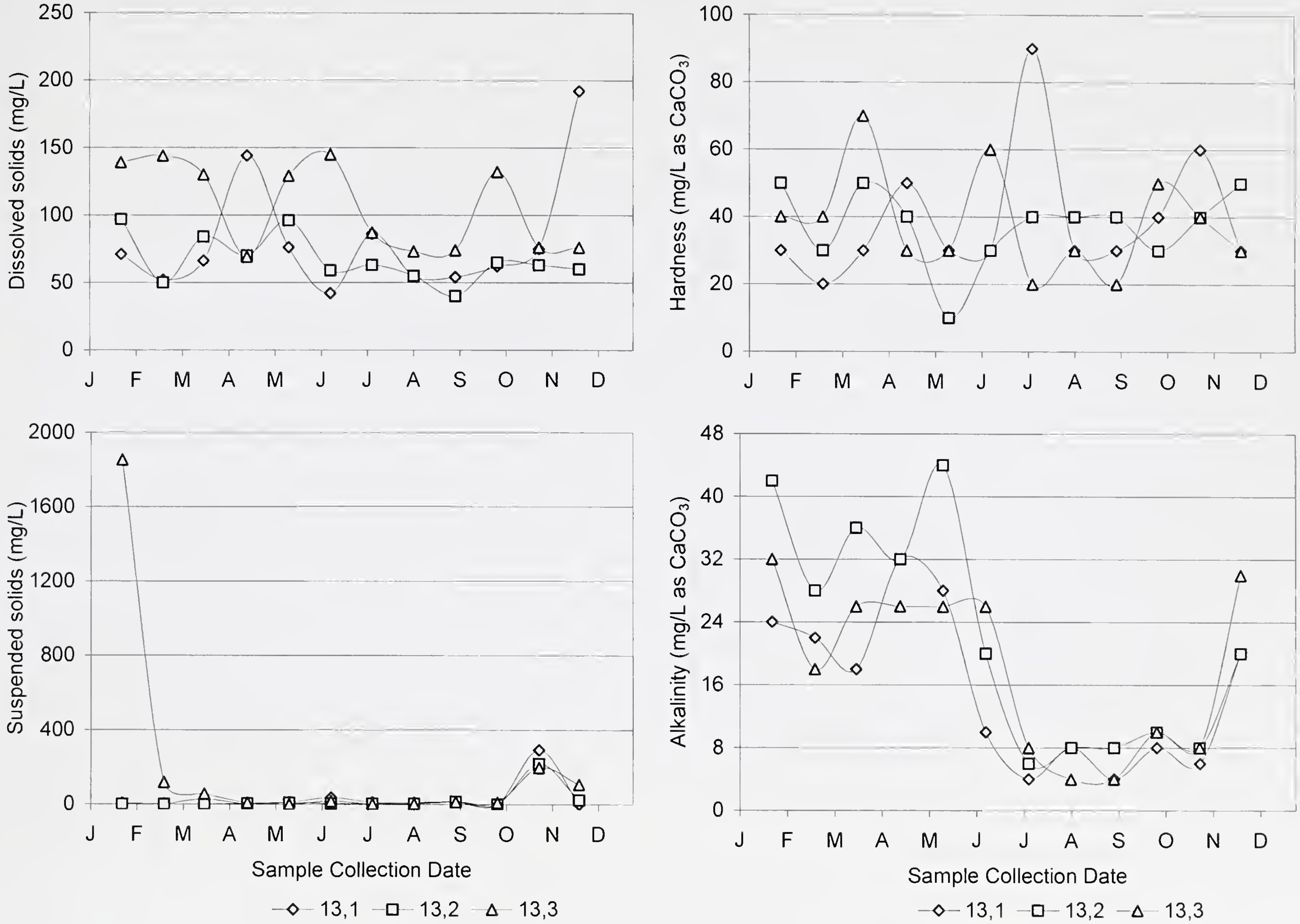


Fig. 13-4. 2002 filtered and total phosphorus, ammonium-N, and nitrate-N measurements for Burney Branch Creek.

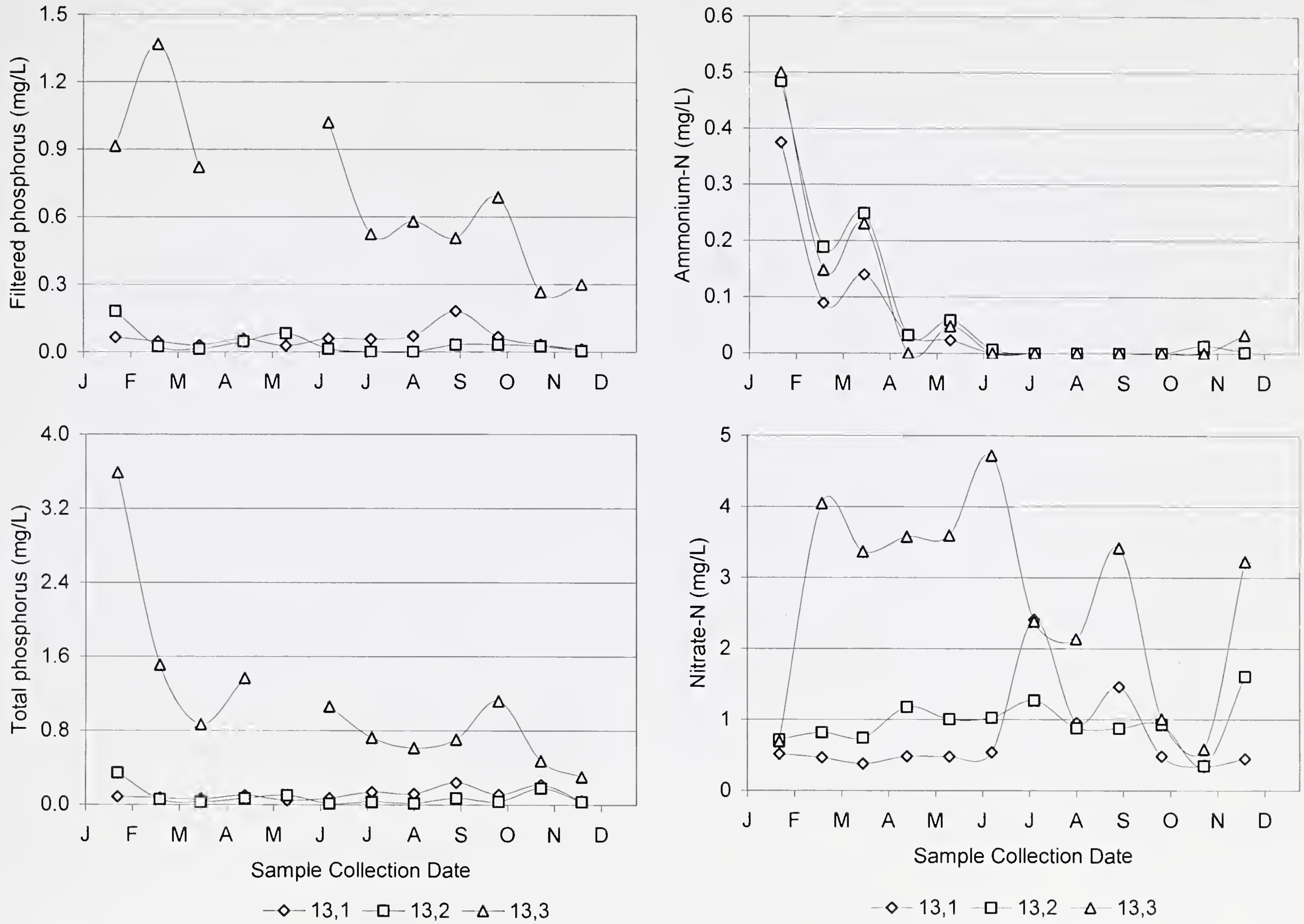


Fig. 13-5. 2002 nitrite-N, total nitrogen, fecal coliform, and enterococci measurements for Burney Branch Creek.

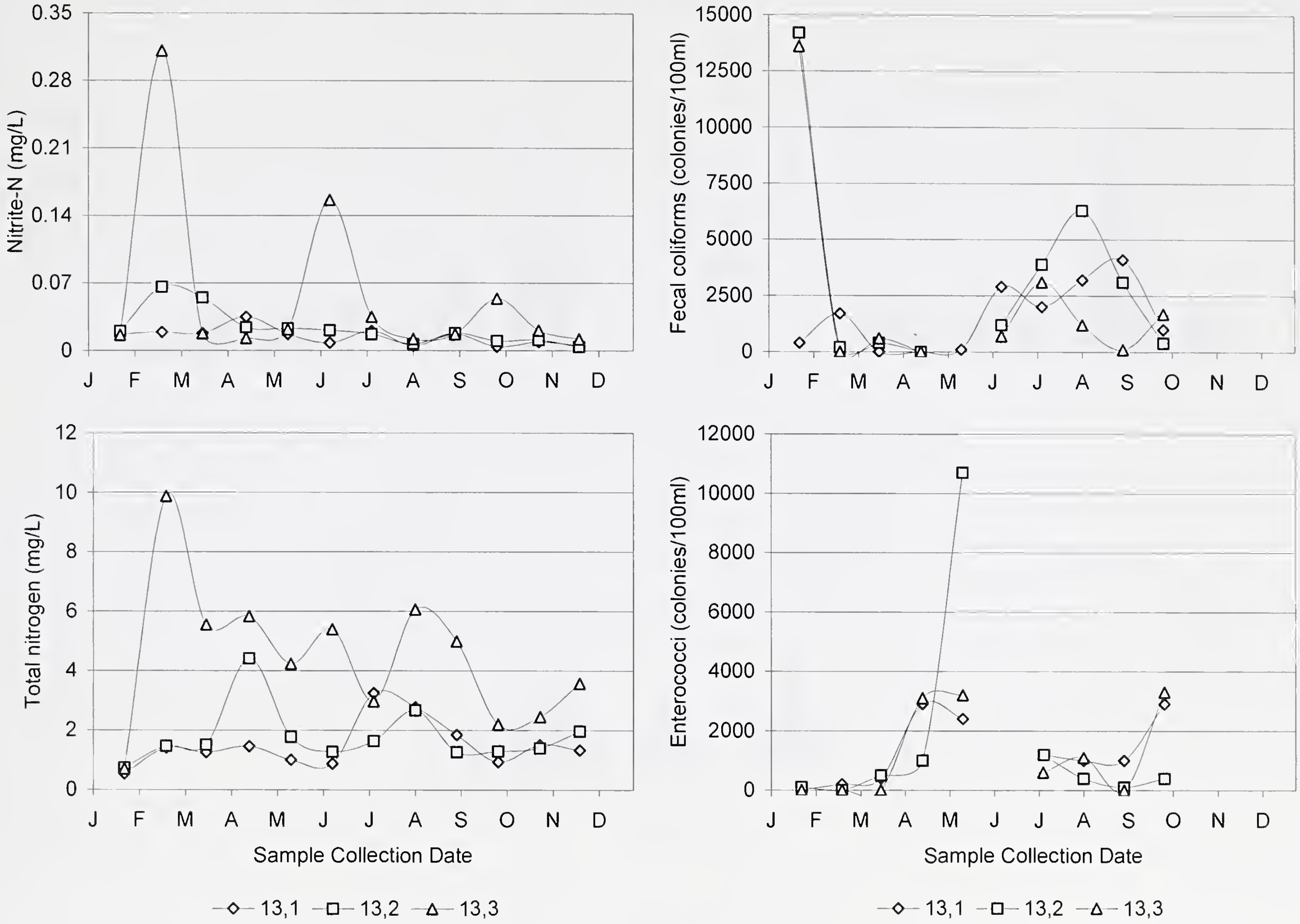


Fig. 13-6. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Burney Branch Creek sites 13,1, 13,2, and 13,3.

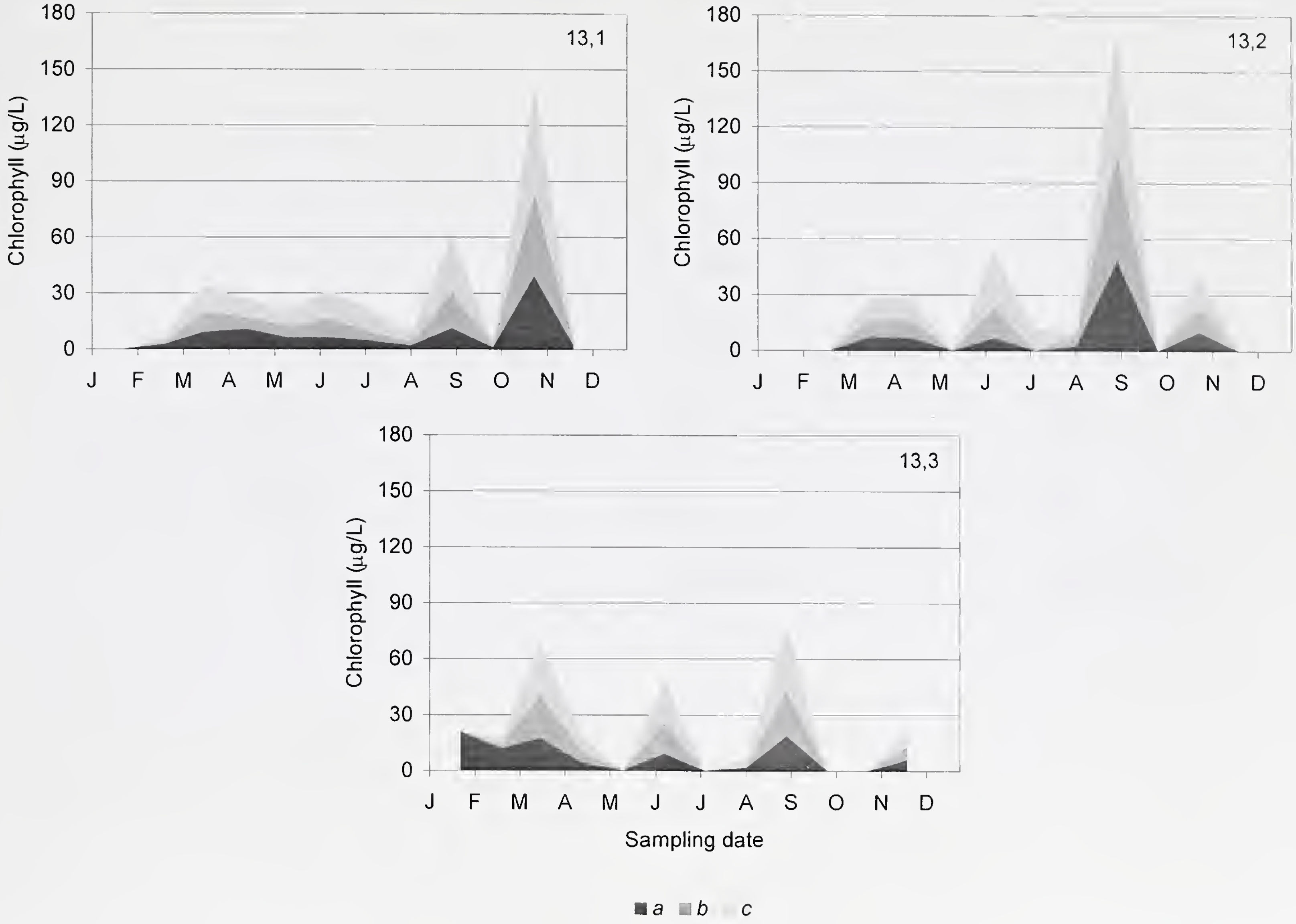


Fig. 13-7. 2002 seasonal pH measurements for Burney Branch Creek.

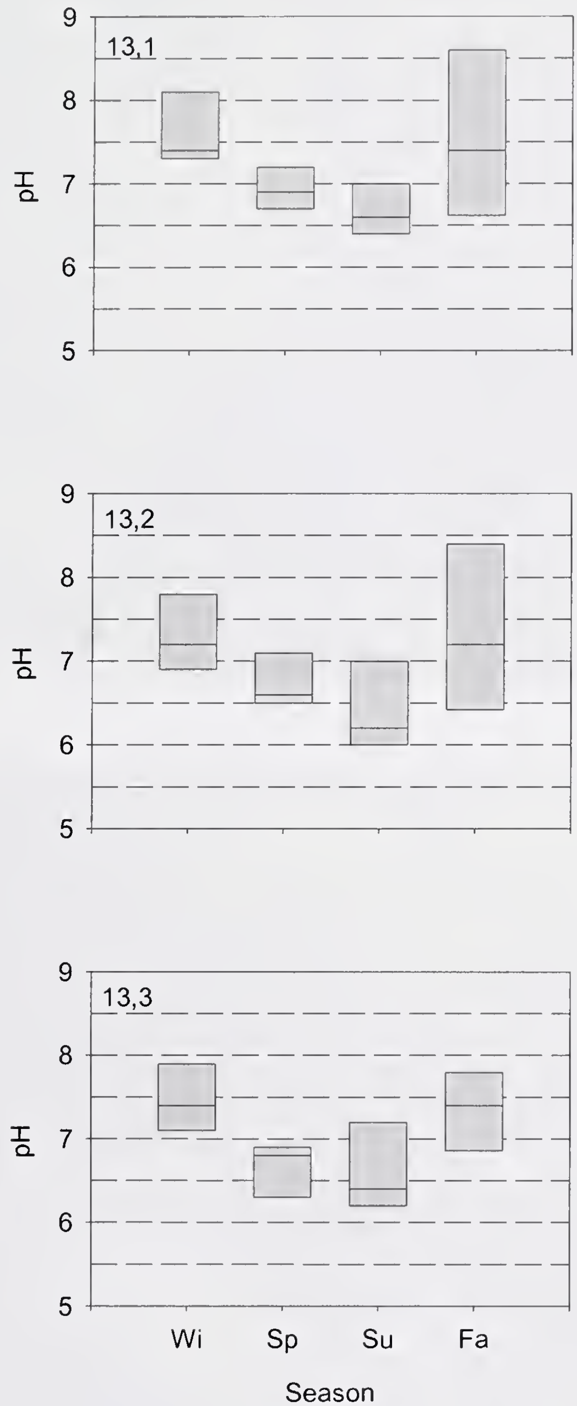
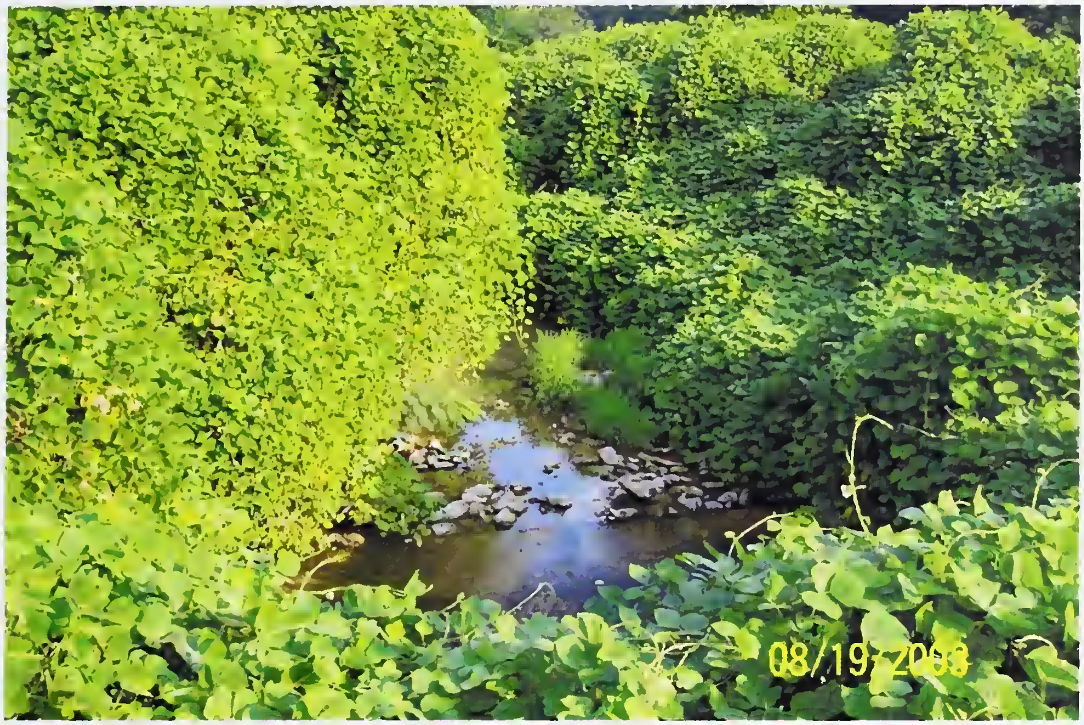


Figure D. Burney Branch Creek site 13,3 (A) upstream and (B) downstream.

A



B

Fig. 17-1. 2002 water depth, temperature, dissolved oxygen, and conductivity measurements for Yalobusha River.

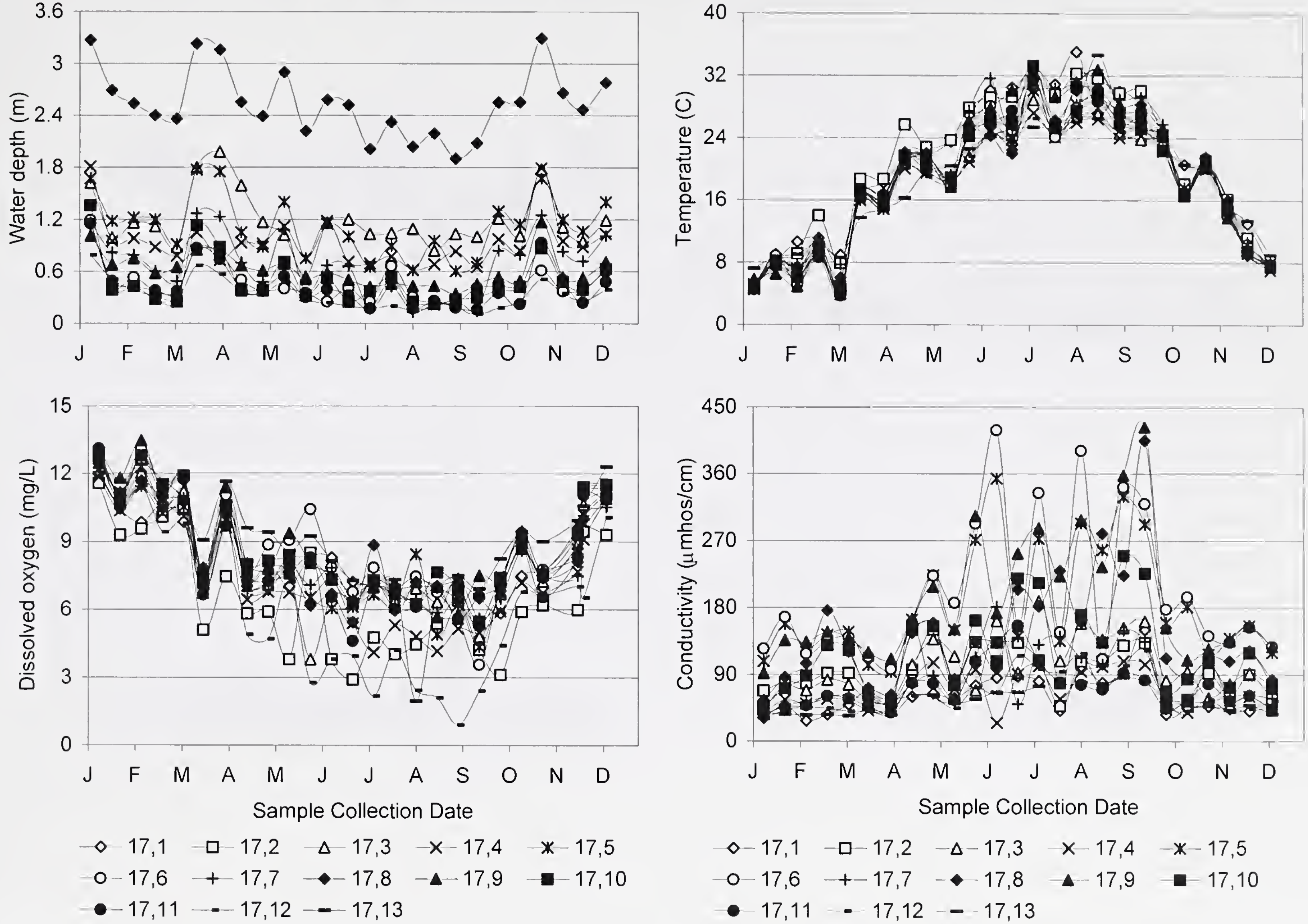


Fig. 17-2. 2002 pH, chlorophyll *a*, turbidity, and total solids measurements for Yalobusha River.

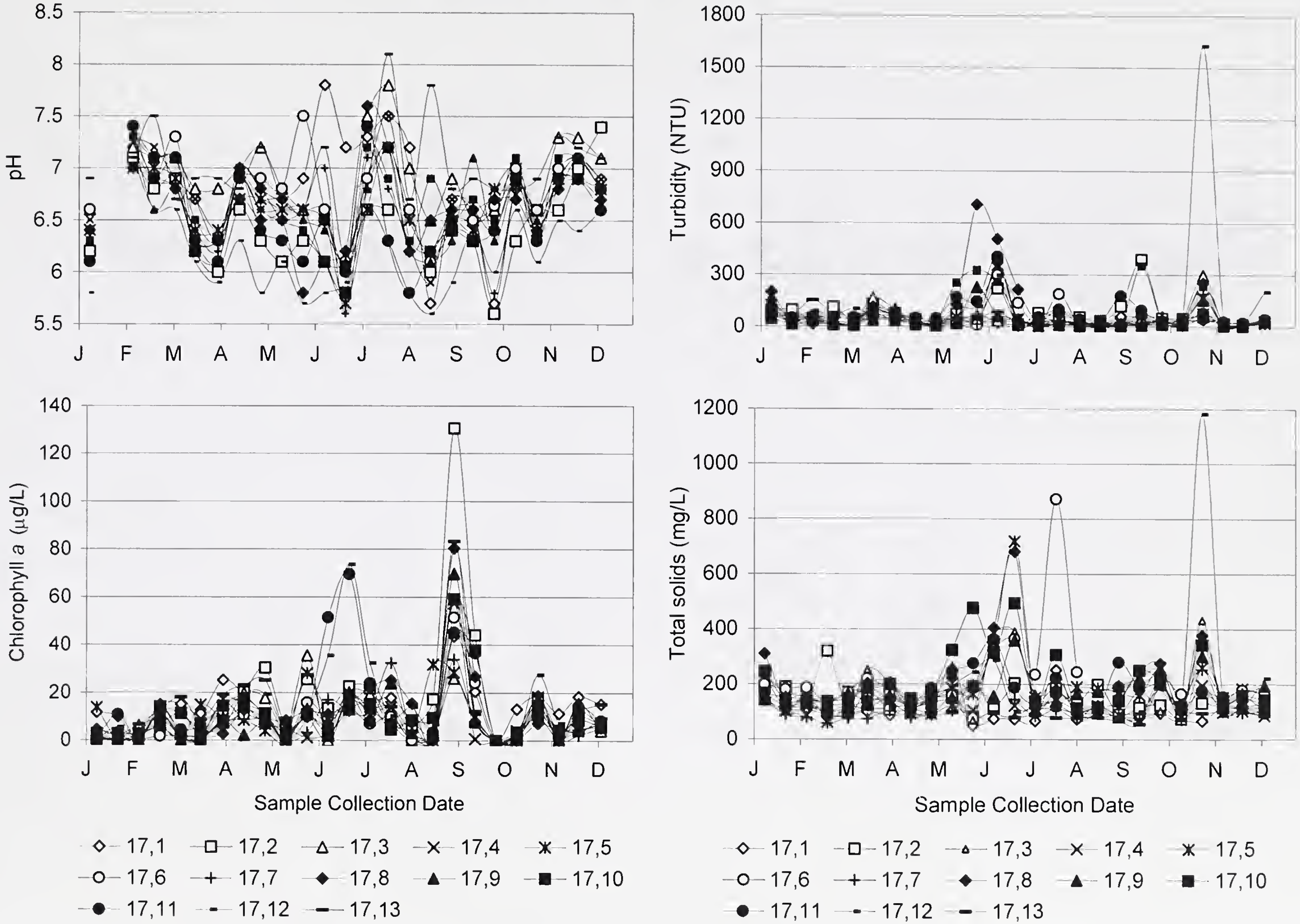


Fig. 17-3. 2002 dissolved and suspended solids, hardness, and alkalinity measurements for Yalobusha River.

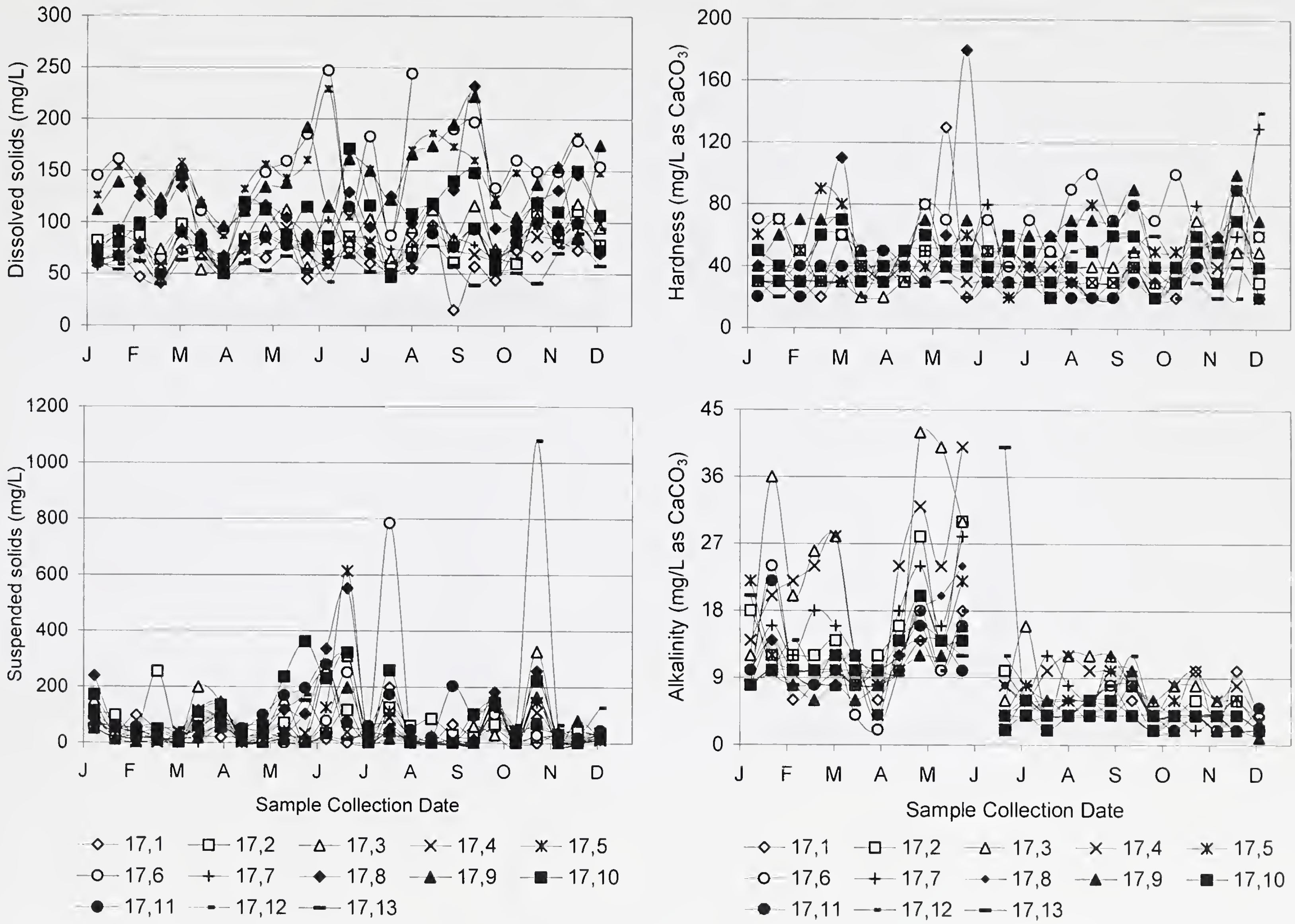


Fig. 17-4. 2002 filtered and total phosphorus, ammonium-N, and nitrate-N measurements for Yalobusha River.

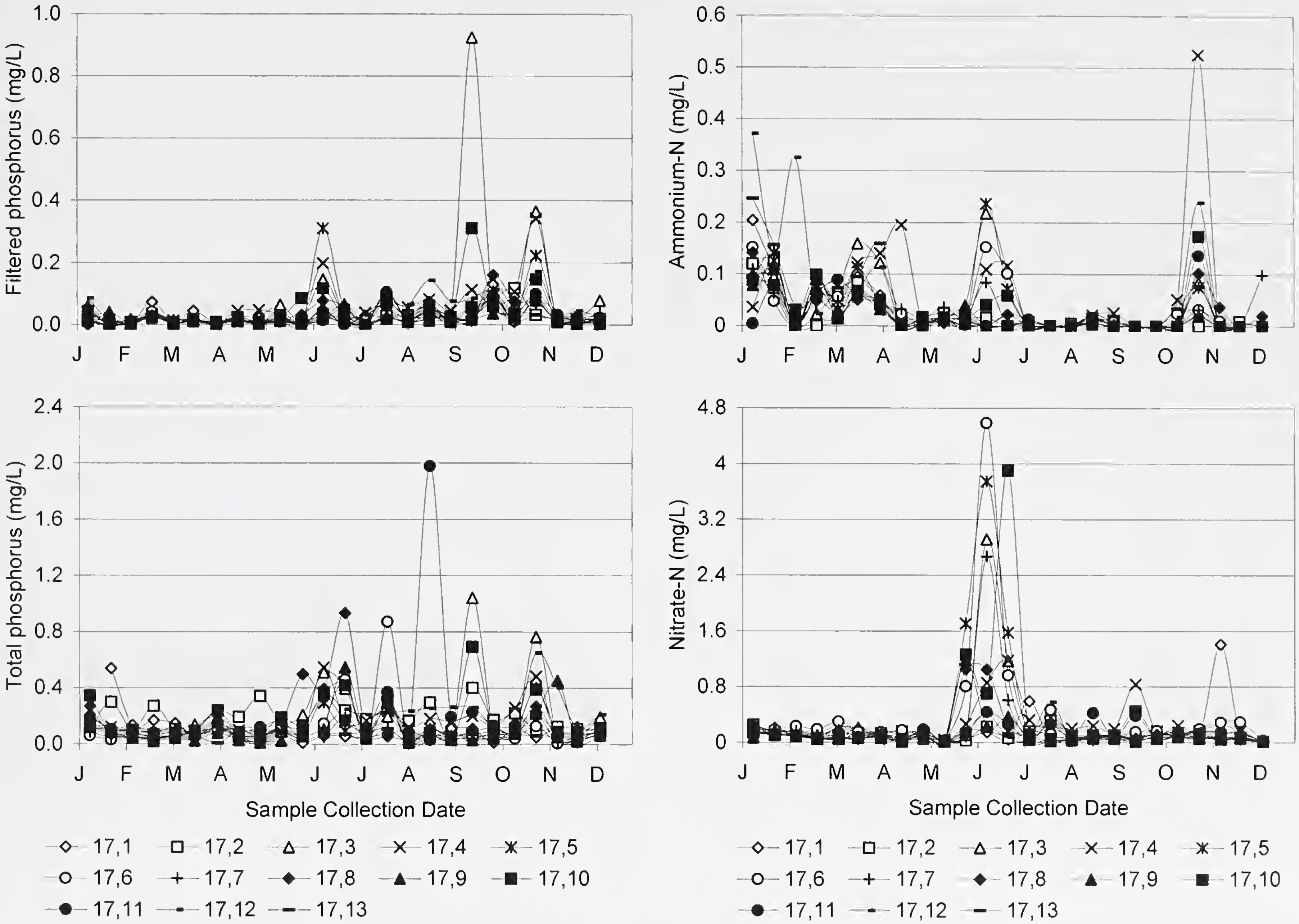


Fig. 17-5. 2002 nitrite-N, total nitrogen, fecal coliform, and enterococci measurements for Yalobusha River.

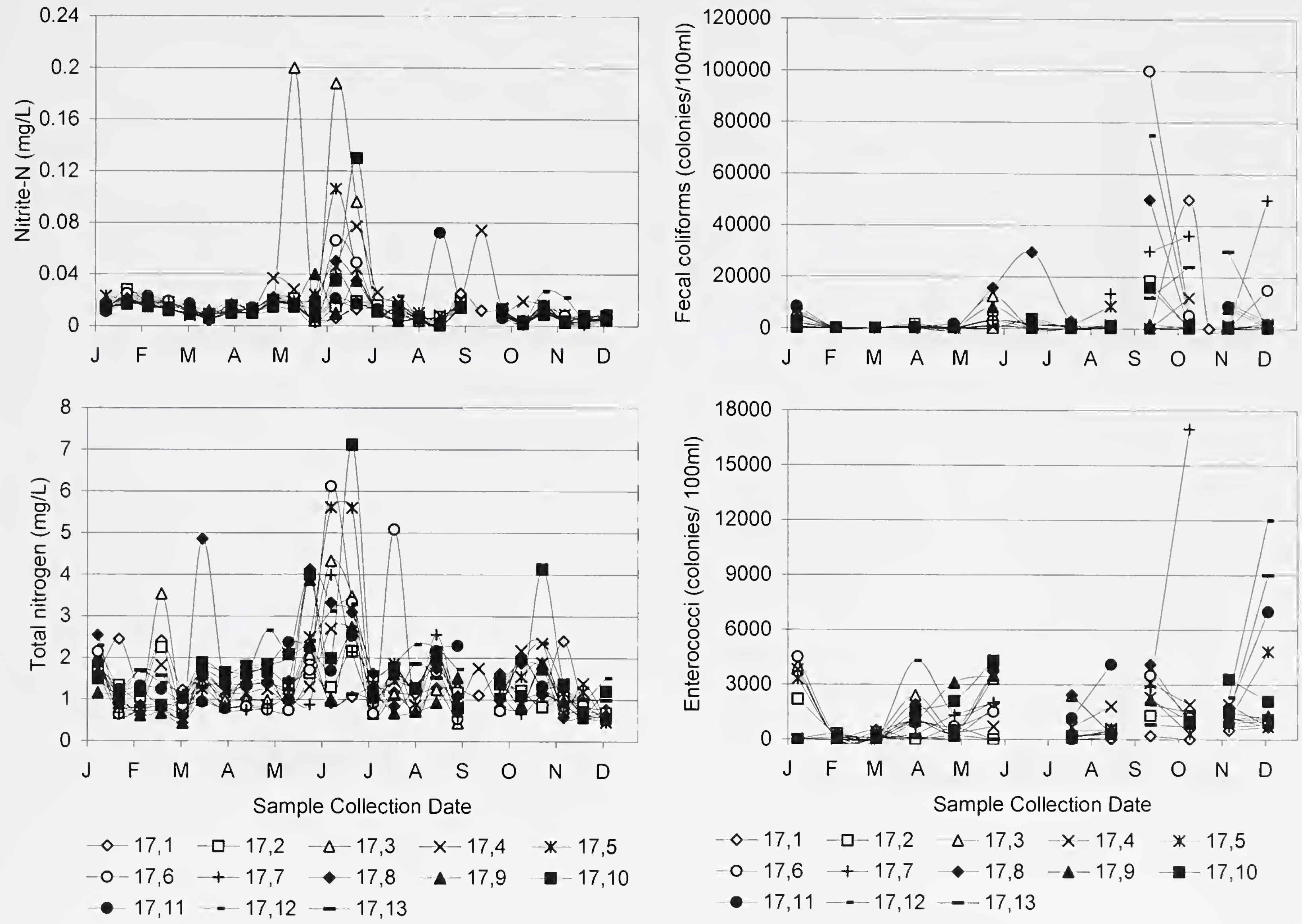


Fig. 17-6. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Yalobusha River sites 17,1, 17,2, 17,3, and 17,4.

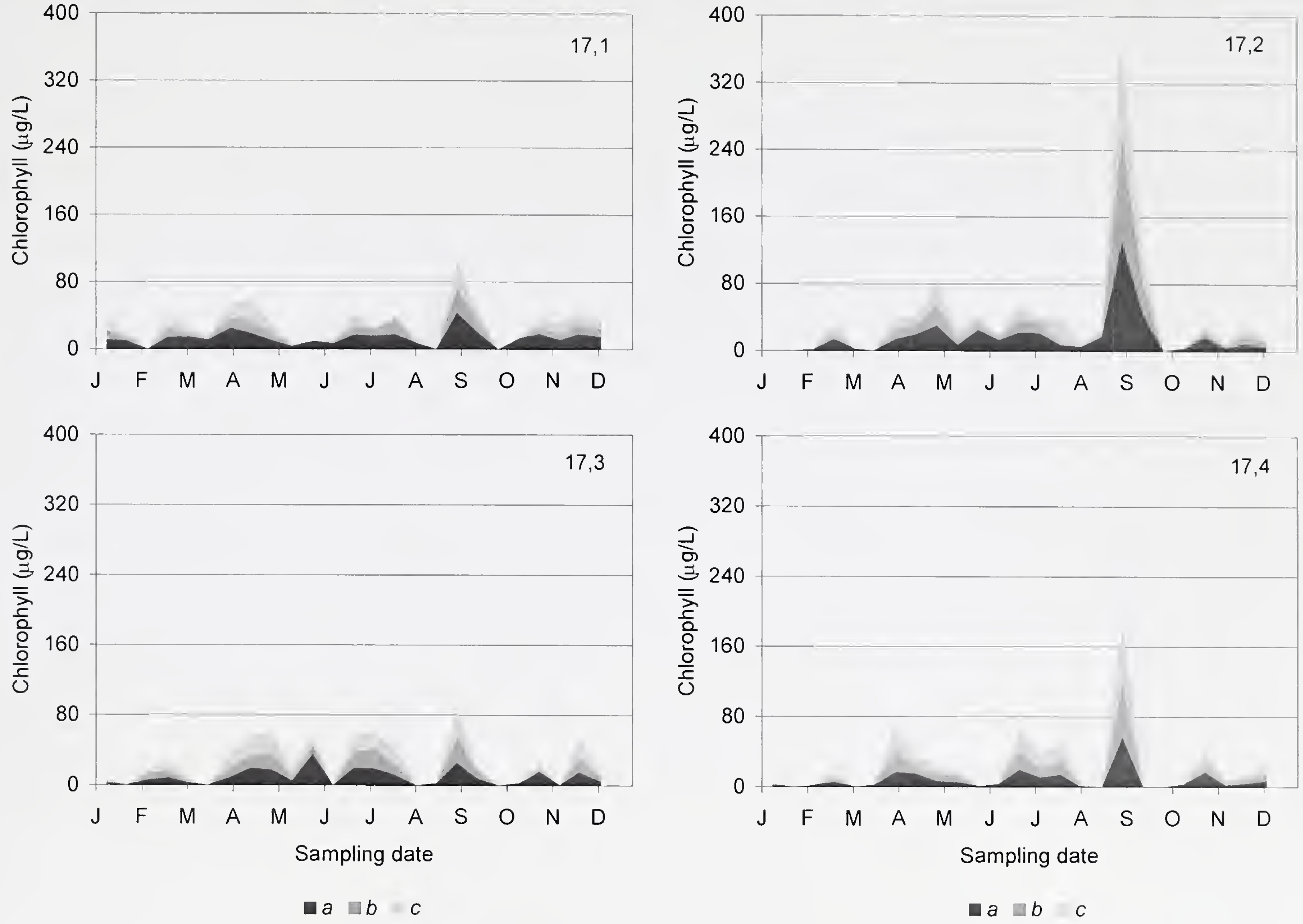


Fig. 17-7. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Yalobusha River sites 17,5, 17,6, 17,7, and 17,8.

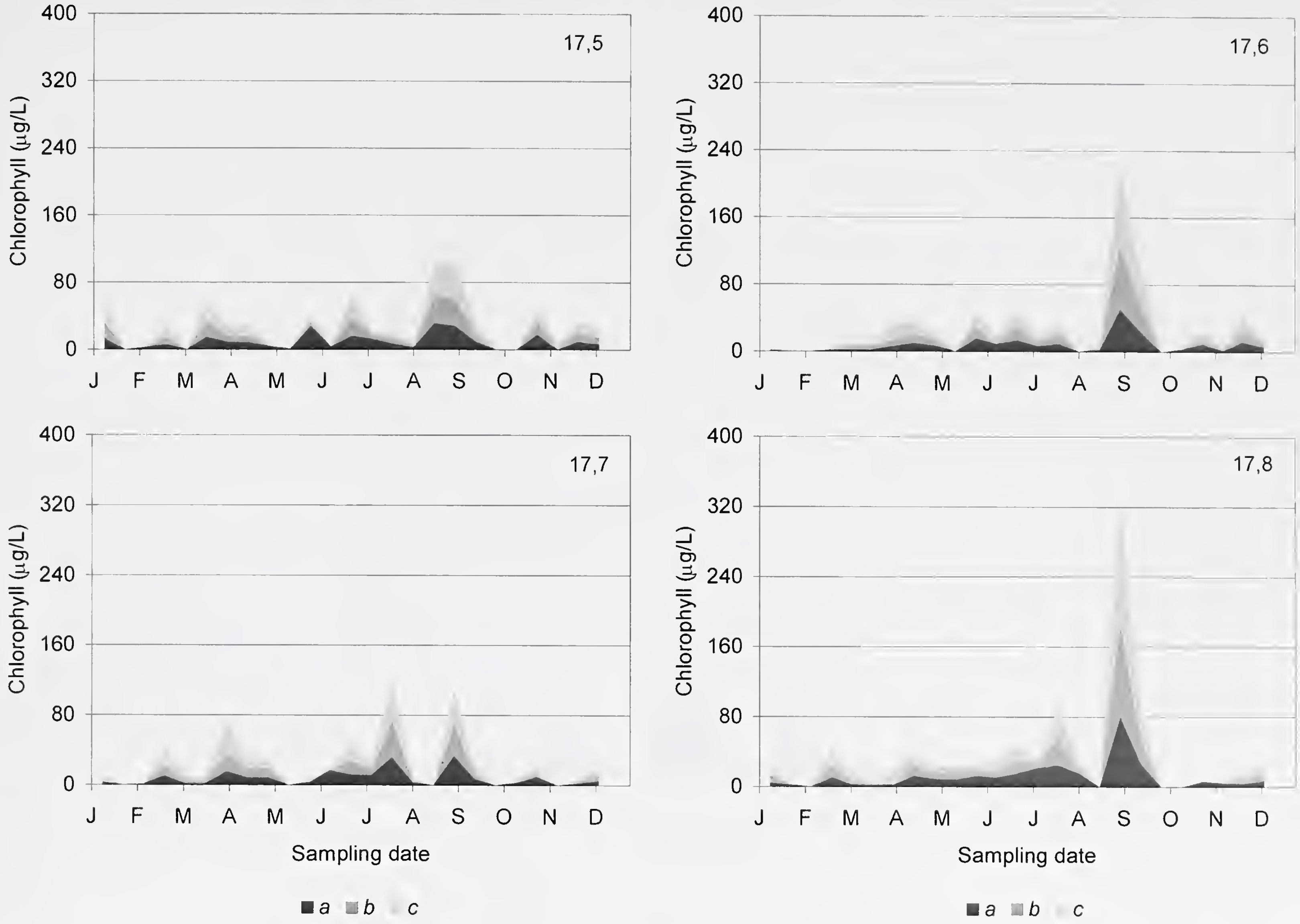


Fig. 17-8. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Yalobusha River sites 17,9, 17,10, and 17,11.

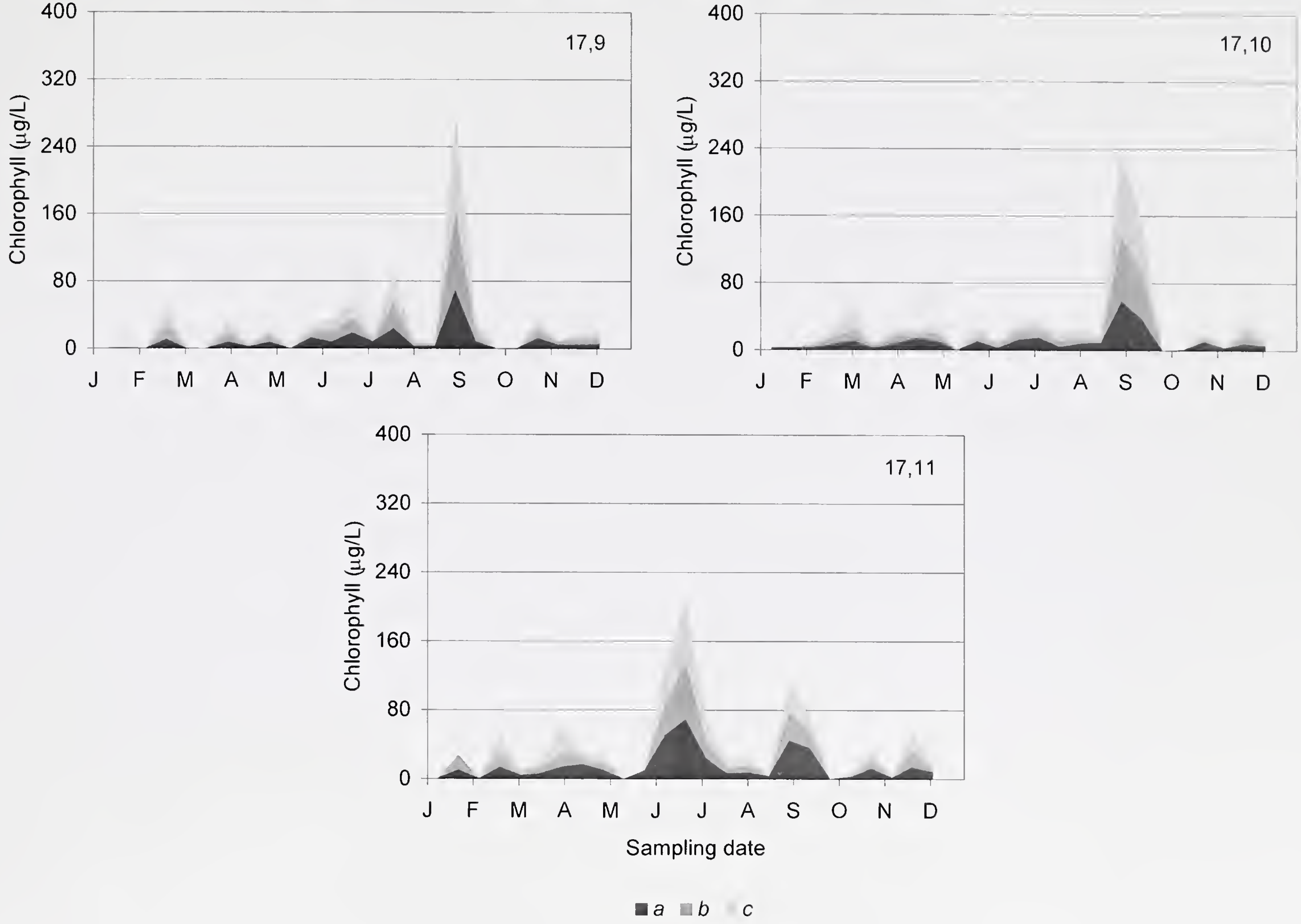
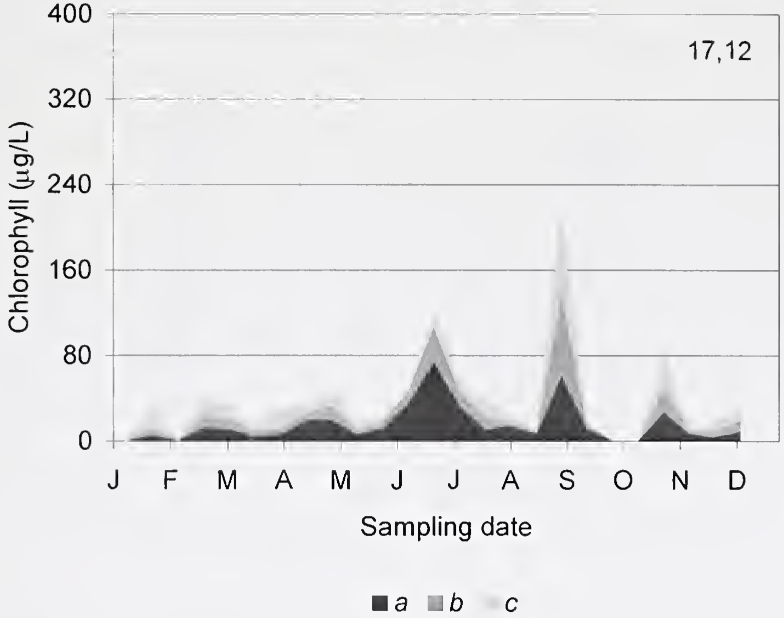


Fig. 17-9. 2002 total chlorophyll measurements as *a*, *b*, and *c* for Yalobusha River sites 17,12 and 17,13.



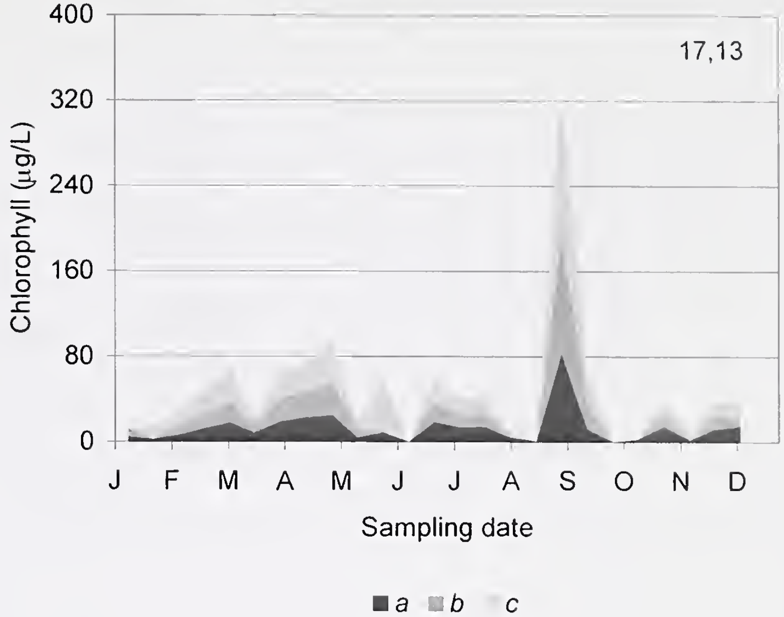


Fig. 17-10. 2002 seasonal pH measurements for sites 17,1-17,8 of the Yalobusha River.

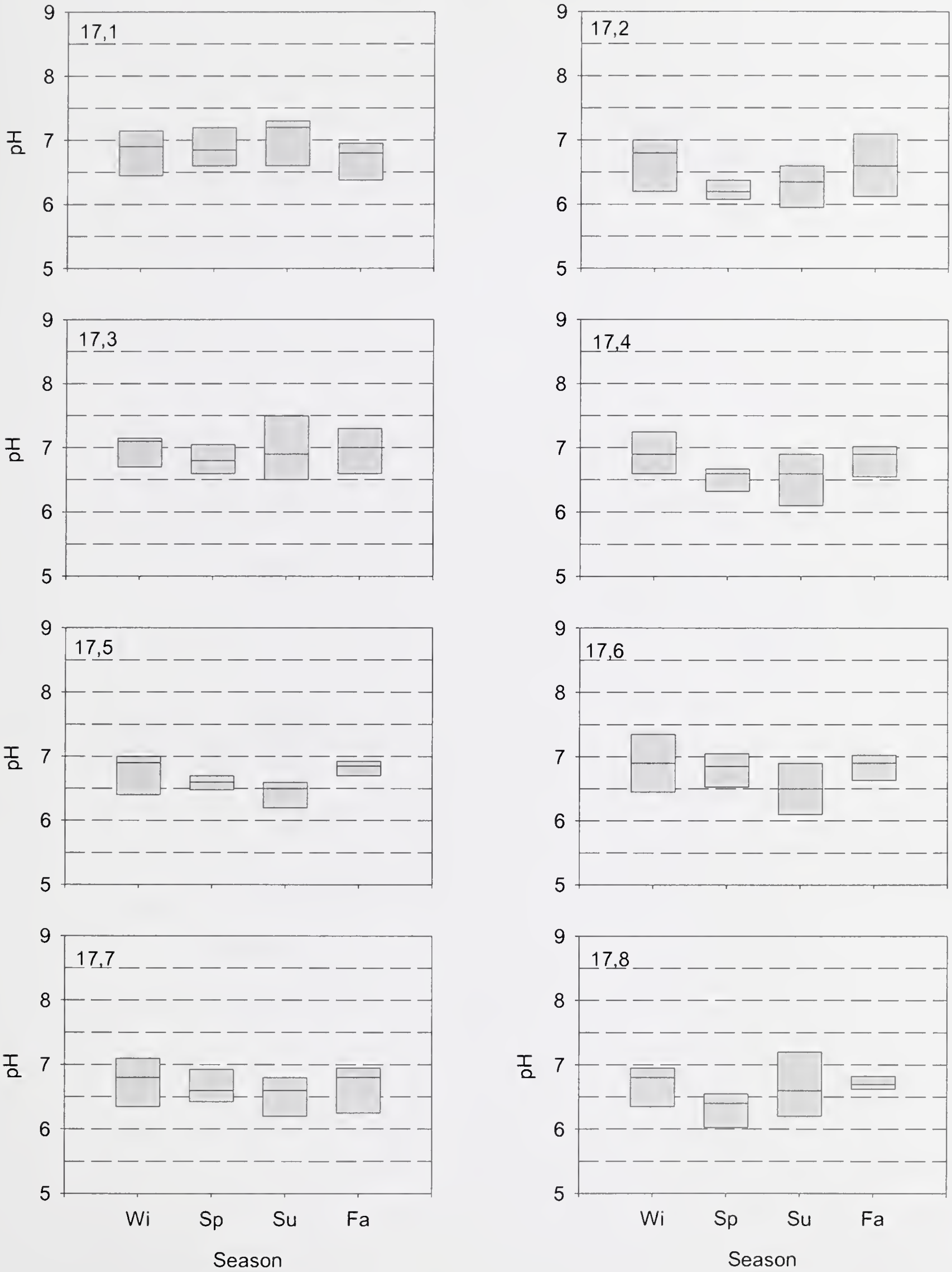


Fig. 17-11. 2002 seasonal pH measurements for sites 17,9-17,13 in the Yalobusha River.

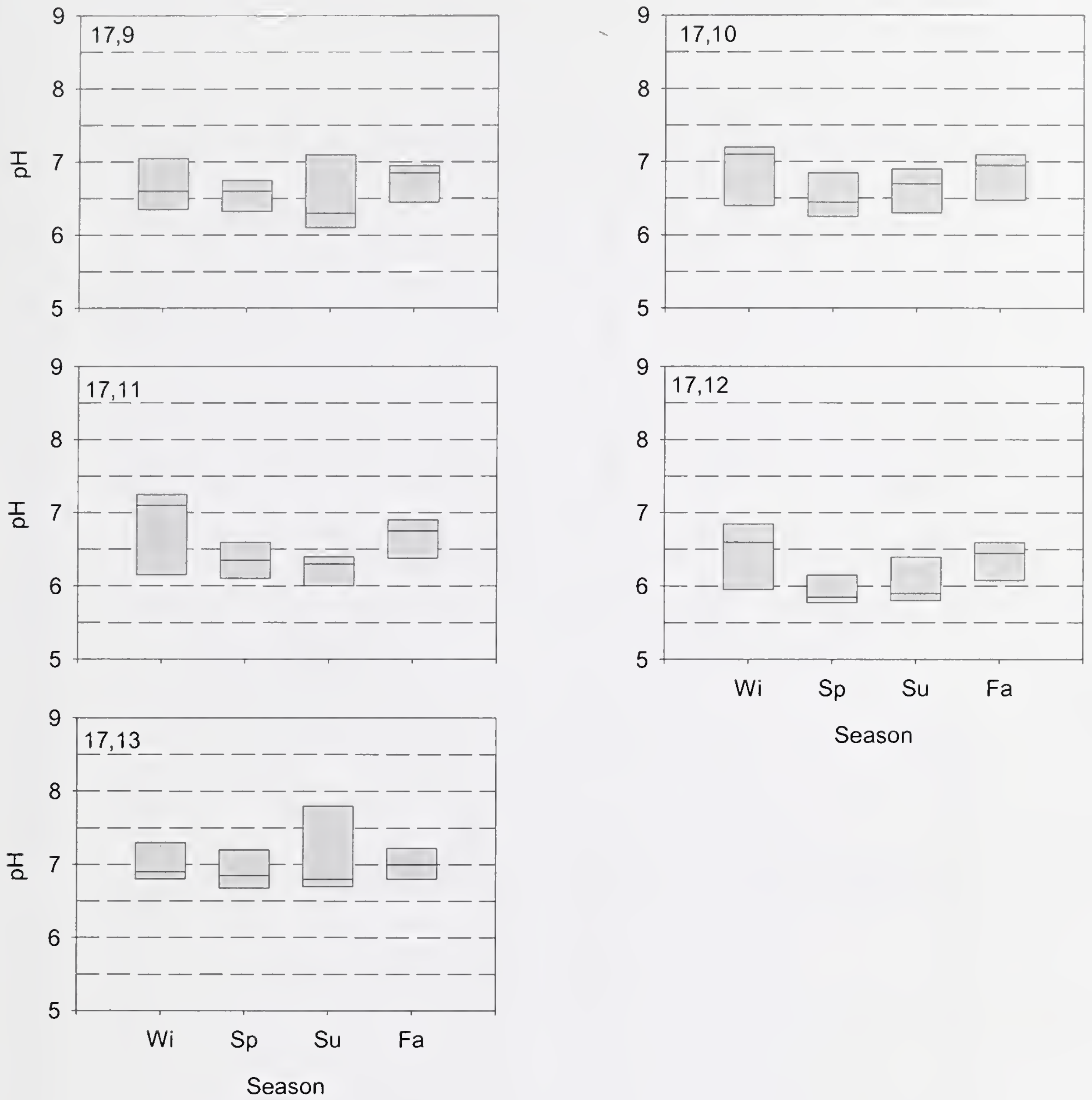


Fig. E. 2002 daily precipitation totals for Otoucalofa, Long, Hotophia, and Abiaca Creeks. Solid triangles represent sampling dates. Climatological data from USDC, NOAA (USDC 2002a-l).

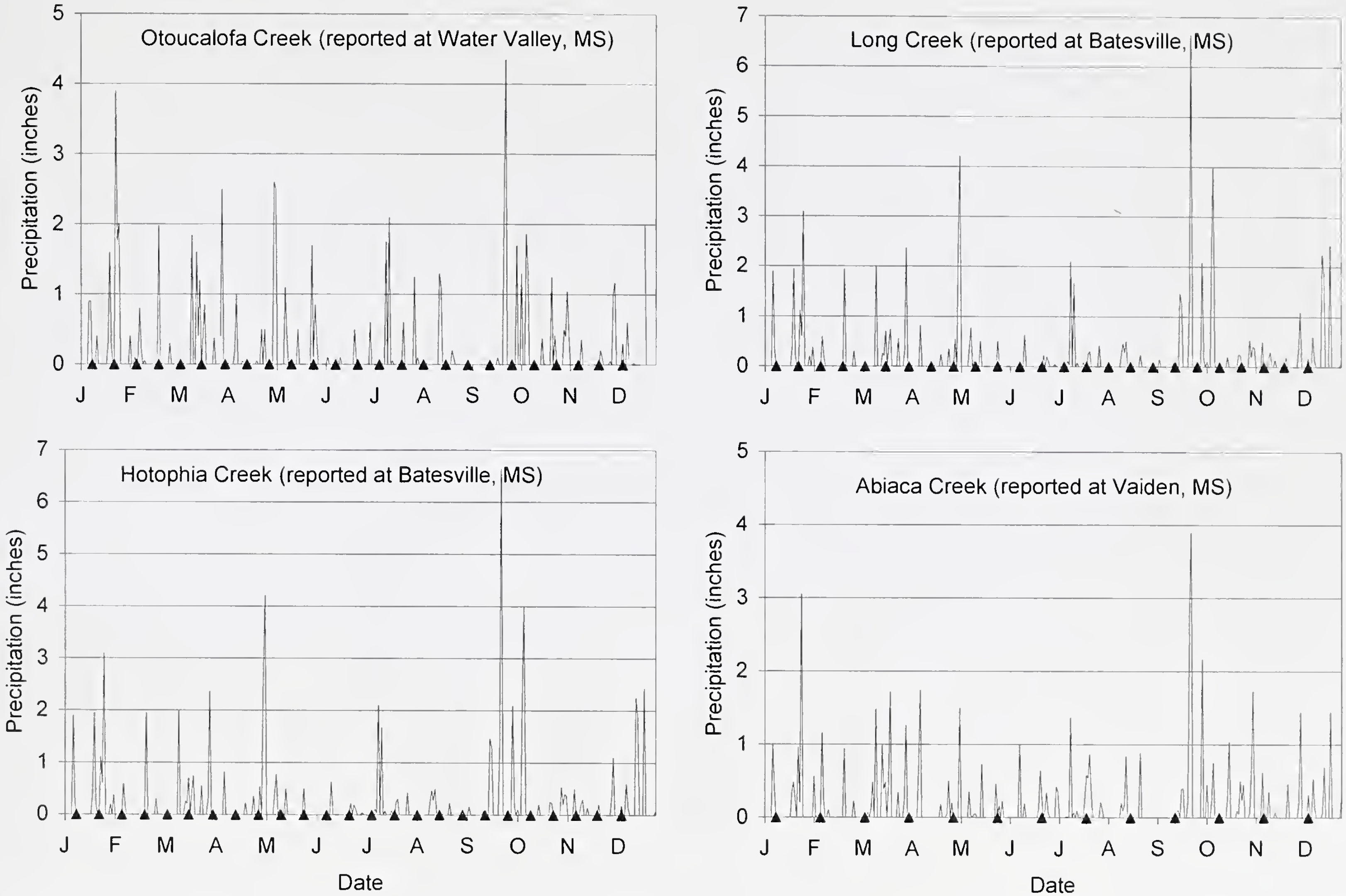


Fig. F. 2002 daily precipitation totals for Toby Tubby Creek, Burney Branch Creek, and Yalobusha River. Solid triangles represent sampling dates. Climatological data from USDC, NOAA (USDC 2002a-l).

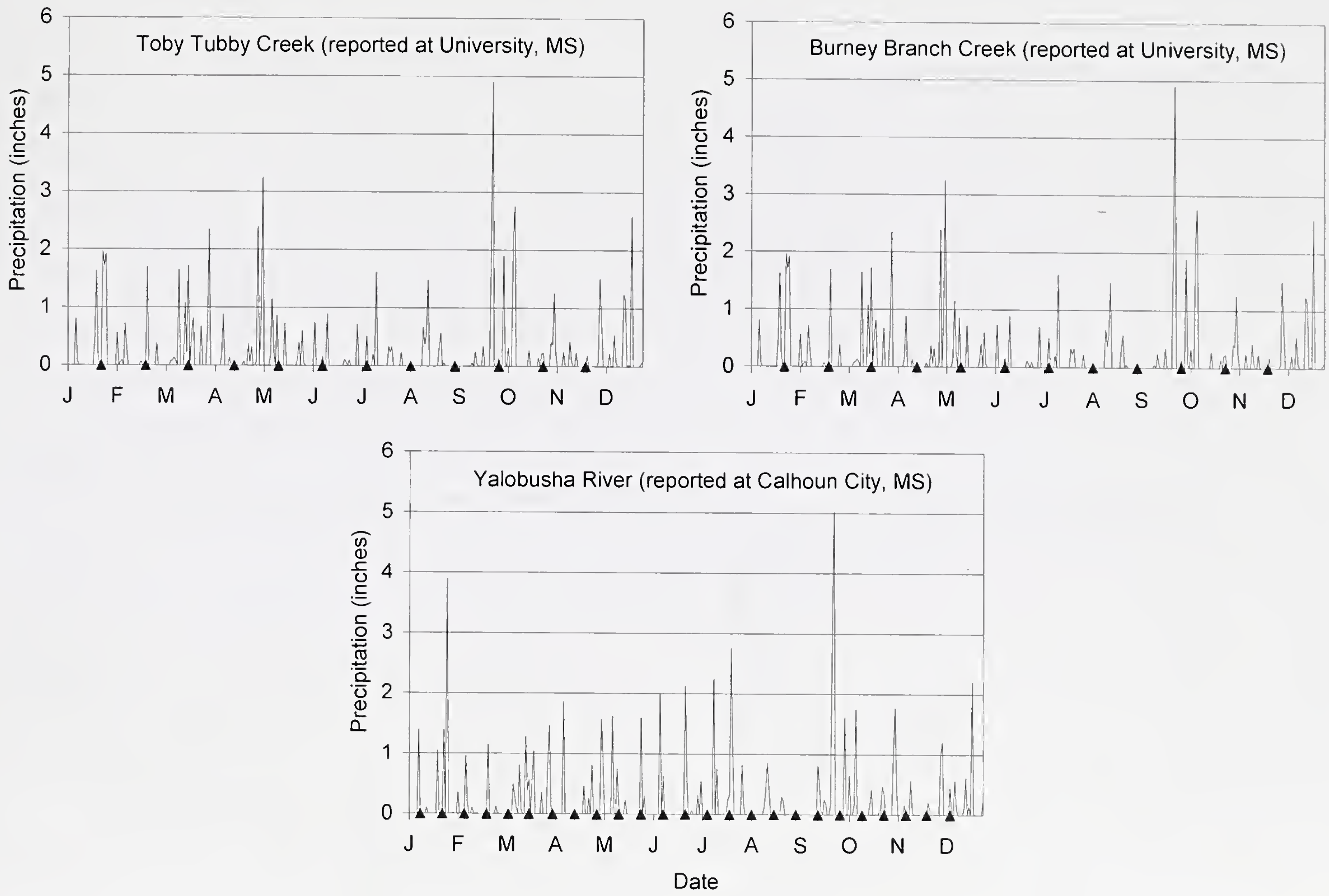


Fig. G. 2002 mean daily discharge or gauge height for Abiaca Creek, Toby Tubby Creek, Burney Branch Creek, and Yalobusha River. Solid triangles represent sampling dates. Data from USGS, Water Resources (USGS 2003).